THE WEEK'S EVENTS

Morgan Asks Court to Reinstate Him

Ousted TVA director asks back salary and recognition as chairman of board of directors

Five days before the congressional committee investigating the Tennessee Valley Authority was scheduled to begin its hearings, Arthur E. Morgan, who was removed last March by the President from his post as chairman of the board of directors of the TVA, filed suit July 6 in Knox County Chancery Court at Knoxville challenging his removal.

Sues for salary

Morgan brought suit against the TVA as a corporation, asking back salary of $2,916. He also sought a declaratory judgment declaring the invalidity of his removal by the President and of the subsequent appointment of H. A. Morgan as chairman of the board. He sought to have it established that he is still chairman of the board and asked an ord that the incumbent directors recognize him as such.

The suit was not filed in the federal court because the amount involved was less than $3,000.

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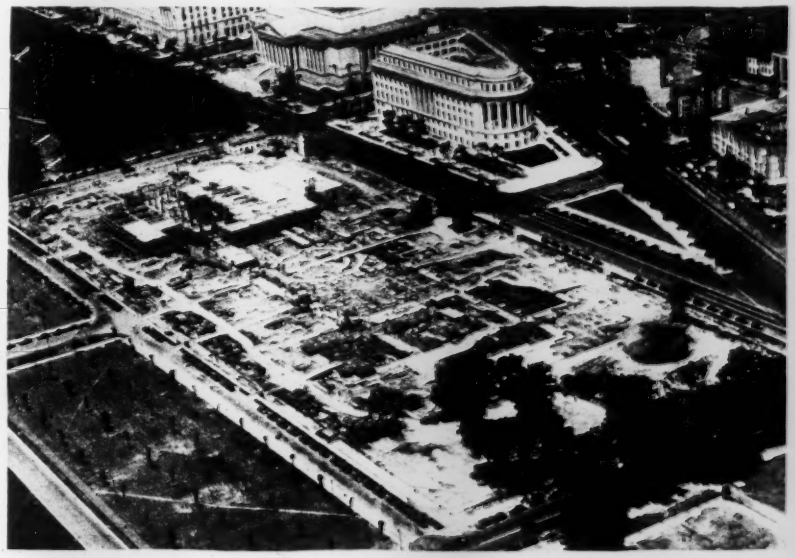
PWA Restricts Allotments For Public Power

Putting into effect a promise made by administration spokesmen during the Senate debate on the PWA appropriation act, PWA Administrator Ickes has announced that no allotments will be made to municipalities for power projects competing with existing systems unless PWA is satisfied that the municipalities have been unable to acquire, on reasonable terms and conditions, the facilities of the competing private utilities, after negotiations carried on in good faith.

Ickes said that this policy would not apply in cases where a public project does not duplicate any severable portion of a private utility system. It does not apply to extensions of an existing municipal plant or to projects which will provide power to be used for proprietary needs of a municipal agency and is not to be sold to the general public.

Likewise, Ickes said, the new policy does not apply to projects for the construction of power facilities handling power to be sold to agencies which may previously have purchased their power at wholesale from a privately owned utility. These projects, he said, usually have no readily identifiable private utility facilities for which the public agency applying for the loan or grant could reasonably be required to make an offer of purchase in order to qualify.

The new policy will not affect projects for which allotments have already been made.



FOUNDATIONS COMPLETED FOR NATIONAL ART GALLERY

CONSTRUCTION WORK on the foundation and retaining walls of the National Gallery of Art in Washington, gift of the late A. W. Mellon, was completed July 3, one year after ground was broken for the structure.

Because rock level lies about 150 ft. below street level, the gallery is founded on about 7,000 concrete piles, construction of which involved pouring of more than 50,000 cu.yd. of concrete. This was necessary to remove 20-year old foundation and piling of the proposed George Washington memorial building.

The gallery's retaining wall, which is now substantially completed, is of reinforced concrete to the top of the main gallery floor, the first floor above street level. Work on the upper walls, of steel and marble, will begin this summer.

The building is to be 784 ft. long and 305 ft. wide. The central rotunda will be 100 ft. in diameter and 100 ft. high.

MAJOR NEWS

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New Prices on Cement And Steel Pipe

Eastern cement manufacturers raise wholesale price, while steel pipe price at Chicago falls

Wholesale cement prices on the Eastern Seaboard were raised this past week 17c. a barrel in Northern New Jersey, 27c. in New York and Long Island and 50c. in Boston, whereas they were lowered 5 to 10c. in Southern New Jersey and 27c. in Philadelphia and Baltimore.

These price changes were precipitated by an extension of the basing-point system when the Allentown Portland Cement Corp. made Evansville and Conshohocken basing points and reduced prices there.

The wholesale price in New York City becomes $2.37 a bbl. subject to 40c. refund for cloth sacks and 10c. for cash in 15 days. The delivered price has not been set as we go to press but is expected to be about $2.70.

The 27c. increase in New York City keeps the wholesale price 10c. lower than before the 37c. reduction of 1936, put into effect to meet foreign competition. The recent increase in freight rates amounting to 4c. per bbl. was absorbed by the cement companies.

Steel pipe prices

Price at Chicago on butt-weld standard steel pipe up to and including 3-in. was reduced last week one point or $2 a ton. The Chicago price will be only one point less discount compared with Pittsburgh, Lorain and also Youngstown which has just been made a basing point by Youngstown Sheet and Tube Co. Lap weld pipe price at Chicago remains unchanged at 2 points less discount than Pittsburgh.

PERSONAL

EDWARD L. MORELAND, head of the Department of Electrical Engineering at Massachusetts Institute of Technology since 1935, was named dean of engineering there June 2, following the resignation of Vannevar Bush, who has been elected president of the Carnegie Institute. Moreland received undergraduate education at Johns Hopkins University and took graduate work at M.I.T., receiving an M.S. degree in 1908. Since then he has been in electrical consulting work, and he became head of electrical engineering in 1935.

CHARLES L. WARTELLE has been appointed city engineer at Seattle, succeeding N. A. Carle. Immediately after his graduation in 1907 from the College of Engineering of the Louisiana State University, Wartelle joined the Seattle engineering department, serving until 1933 in various capacities ranging from draftsman to district engineer. In that year he became engineering examiner for PWA, and he became regional chief engineer for that agency in 1935. During the war, Wartelle served as a first lieutenant in the Corps of Engineers.

W. V. BARRY, city engineer of New Haven, has been appointed to the additional post of director of public works, thus combining the duties of the two positions.

ROBERT H. RANDALL of Toledo, Ohio, has been designated by President Roosevelt to represent the United States at the first preparatory meeting of the International Public Works Committee at Geneva, Switzerland, beginning June 27. Randall is now consultant for the Tennessee Valley Authority and for the National Resources committee on state and regional planning.

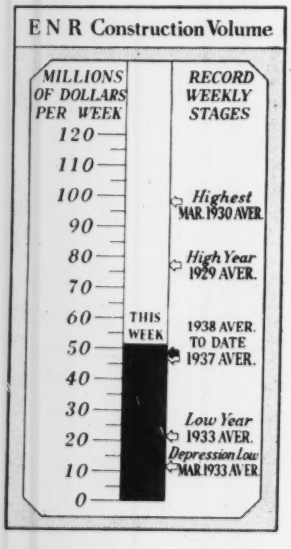
J. STANLEY RAFFETY, sanitary engineer of the Hamilton County, Ohio, General Health District, has been appointed manager of Laurel Homes, Cincinnati housing project. Raffety is a graduate in civil engineering of Grinnell College and Massachusetts Institute of Technology. After his graduation he worked with the Ferro Concrete Construction Co. of Cincinnati and was later county sanitary engineer there.

CONTRACTS AND CAPITAL

THE NEW STEEL PRICE structure makes necessary a revision from 233.10 to 232.29 in the *ENR* construction cost index for July for which data were not available last week.

The steel component in the construction cost index has always been computed from the Pittsburgh base price for structural shapes and plate. Selection of this price was made under the "Pittsburgh plus" system of pricing steel which was preserved in effect by the differentials set up in 1924 when Chicago and Birmingham were added as basing points for structurals under the multiple basing point system of pricing.

Now with differentials eliminated and effective price cuts of $3 per ton at Pittsburgh, $4 at Chicago and $6 at Birmingham, it is necessary to weight these cuts to get the effective price change for the national construction cost index. Weights of 24-11-5 for Pittsburgh, Chicago and Birmingham, represent relative production of structural shapes and plates in these three producing areas and give an average price cut of $3.65 per ton compared with the $3 Pittsburgh cut used in computing the index last week. The new values based on this weighted average price are reported in the accompanying table.



CONTRACTS

(Thousands of dollars)

	Week Ending July 15 1937	July 7 1938	July 14 1938
Federal	$3,826	$38,675	$5,223
State & Municipal	32,171	31,547	27,629
Total public	$35,997	$70,222	$32,852
Total private	23,440	8,100	19,568
TOTALS	$59,437	$78,322	$52,420
Cumulative 1938	(28 weeks)		$1,385,673
1937	(28 weeks)		$1,427,341

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1937 28 Wk.	1938 28 Wk.
NON-FEDERAL	$850,537	$1,221,448
State & Mun. bonds	291,596	355,588
Corporate securities	285,087	191,938
PWA loans, grants	43,915	284,832
RFC loans	29,939	65,291
U.S.H.A. loans	....	111,070
R.E.A. loans	....	11,229
Federal Aid-Highways	200,000	201,500
FEDERAL	....	1,122,805
TOTAL CAPITAL	$850,537	$2,344,253

FHA MORTGAGES

	Cumulative 1937 26 Wk.	1938 26 Wk.
Mortg. selected for appraisal	$343,000	$483,489

ENR INDEX NUMBERS

Index Base		1913	1926
Construction Cost	July	232.29	111.66
Building Cost	July	194.39	105.08
Volume	June	165	73

BRIEF NEWS

DIVERSION of the Skagit River near Seattle, Wash., was accomplished June 28, permitting start of construction on the $4,000,000 Ruby Dam being built for the Seattle City Lighting Department. The river now flows through a diversion tunnel 1,100 ft. long and 30 ft. in diameter through the north canyon wall. The tunnel was completed some time ago, but high water in the Skagit has made it necessary to defer diversion.

THE CLEVELAND city council has authorized installation of 3,000 parking meters for a trial period of one year.

THE BRITISH COLUMBIA Minister of Public Works has announced that his department will invite bids only from selected and representative contractors, instead of by open bidding.

A $5,000,000 BOND ISSUE for highway maintenance and rural road construction will be submitted to Louisiana voters, under the terms of an act recently signed by Governor Leche.

LOW BID on a Procurement Division order for 1,500 bbl. of finely ground standard portland cement in cloth bags and 7,000 bbl. in paper for use in Nevada, was offered by the Pacific Portland Cement Co. of San Francisco, which quoted prices of $1.65 and $1.45 f.o.b. Redwood City. The Santa Cruz Portland Cement Co. quoted the low bid of $2.00 and $1.80 for 5,000 bbl. of finely ground portland cement in cloth and 5,000 bbl. in paper for use in Idaho and Oregon. All bids offer a 10 cent rebate for return of cloth bags.

SIGNS are being installed on U. S. Highway 40 in Illinois at every curve, indicating the speed at which the curves may be traveled safely under normal conditions. The signs were placed after a series of speed surveys by highway safety engineers. The program will be continued until similar signs are placed on all highways in the state system. Theoretical speeds were first calculated on the basis of skid resistance, and then checked by cars equipped with airplane bank and turn indicators.

THE 13-STORY Women's Hospital at Pittsburgh has been erected by welding. Due to the proximity of other hospitals, the city council granted a special construction permit pending passage of a new ordinance incorporating welding regulations into the building code. Welding of the 1000-ton steel framework used 2300 lb. of welding rods. Stone & Webster Engineering Corp. is managing the construction. John L. Mullen Construction Co. was the steel contractor.

WHEN the city of Detroit installed municipal garbage incinerators, it terminated its garbage disposal contract with the Detroit Reduction Co. The Detroit company has sold out its plant to Consolidated Products Co. of New York City, which is planning to sell the equipment piecemeal.

THE PITTSBURGH city council has voted to submit an $8,000,000 bond issue to the voters on Aug. 2 which, if approved, would pay for the city's share of a public improvement program amounting, if PWA grants are received, to $14,500,000.

A MAGAZINE, *Engineering Age*, intended to cover engineering activities in Ohio, began publication with the June issue. Published by Perry T. Ford, secretary of the Ohio State Board of Registration and former president of the Ohio Society of Professional Engineers, it has been endorsed by that society. G. F. Rudisill, editor of *Highway Topics* and of Road Laws of Ohio Manual, is editor of the new magazine.

THOMAS H. MACDONALD, chief of the Bureau of Public Roads, has been appointed by the President as representative of the United States on the commission of technical experts being organized, under terms of the Pan-American Highway Convention, to coordinate the work of the different governments in connection with construction of the Pan-American highway.

DANGER of salt water intrusion into the water sand from which Galveston and Houston, Texas, draw their supplies exists because of the lowering of the fresh water level, according to a report to Governor Allred, drawn up by the committee on groundwater of the Texas Planning Board. The Winter Garden district in south Texas and to a lesser extent, the Texas Panhandle, are also threatened with water shortage. Water-bearing strata, according to the report, have been greatly overtaxed in the east Texas area.

THE AMERICAN delegation to the World Power Congress meeting in Vienna, Germany, Aug. 25-Sept. 2, 1938, will be headed by Commissioner John W. Scott of the Federal Power Commission.

THE WAR DEPARTMENT has approved plans of the New York City Department of Parks for construction of a vertical lift footbridge across the Harlem River from a point near 103rd St. in Manhattan to Ward's Island for the use of pedestrians between Manhattan and Ward's Island Park.

Employment Claims Are Attacked

Conlon says engineering schools lure students by false promises of opportunities

Promises of employment made by school publicity agents and "some visionary professors" in "industrially subsidized engineering schools" are luring youths to those schools, according to Willard S. Conlon, executive secretary of the National Society of Professional Engineers.

Conlon, in a statement released last week, cited a press dispatch from Cleveland which stated that 75 out of 132 graduating engineers from the Case School of Applied Science had received immediate jobs with an average starting wage of $115 a month. Because of overcrowded conditions in the profession and overproduction of engineering schools, Conlon said, most of these graduates will be unable to remain in the engineering profession.

"Thousands of graduates since 1928 never have had an opportunity to practice their profession, and may now be found working as gasoline station attendants, or selling furniture or insurance."

Few stay in profession

Conlon cited figures prepared by D. B. Steinman, New York City consultant and past president of N.S.P.E., showing that of 45,000 living graduate mechanical engineers, 11,000 are employed in positions of professional status, 9,000 have engineering jobs of sub-professional status, and the remaining 25,000 are either unemployed or have been forced out of the profession.

If the present rate of enrollment in engineering schools is not sharply curtailed, according to Steinman, there will be a surplus of 190,000 engineering graduates by 1960.

Conlon quoted a suggestion by Steinman that the number of students in mechanical engineering schools be reduced from 16,000 to 6,000; that the number admitted annually be cut from 6,000 to 2,000; and the number graduating be reduced from 2,500 to 1,200.

Industrial sources on the lookout for low cost engineering services, Conlon said, are partly to blame for the condition. Graduates accept industrial jobs at nominal pay, only to find later that there is no future in the work and that there is a steady pressure of waiting graduates who in turn will take their jobs at even lower wages. This condition causes constant turnover, with a stream of graduates ever ready to take over jobs vacated by disillusioned graduates of earlier classes.

HYDRAULIC FILL AT FORT PECK DAM NEARING COMPLETION

HYDRAULIC-FILL embankment at Fort Peck Dam, stretching for 9,000 ft. across the valley of the Missouri River in Montana, on July 1 contained 95,307,100 cu.yd., about 95 per cent of its ultimate quantity. During June some 3½ million cu.yd. were pumped into the fill by the four hydraulic dredges, two of which are working more than 3 miles from the point of placement. Pipeline length reached a record a few days ago when the dredge *Jefferson* was pumping through 25,180 ft. of 28-in. pipe.

The above airplane view is taken from high over the east abutment. The outlet gate control works are in the foreground, the town of Fort Peck is in the right background. Water storage in the reservoir, which began several months ago, has now reached considerable proportions. The central core pool on the fill, prominent in the picture, is over 1½ miles long.

Experts Approve Pontoon Bridge

Consulting engineer board gives complete approval to Seattle for Lake Washington crossing

Unqualified approval has been given the proposed construction of a concrete pontoon bridge across Lake Washington at Seattle, in a formal report made by a board of consulting engineers appointed last year by state highway director L. V. Murrow. The report estimates cost of the bridge at $7,122,000, including a tunnel at the Seattle approach, connections with a new cutoff to the eastern part of the state, and a series of overhead and undercrossings which will carry traffic into the center of Seattle.

PWA is being asked to approve a 45 per cent grant. The remaining 55 per cent will be met by revenue bonds issued by the Washington Toll Bridge Authority and retired by toll charges of 25c per car, according to the report. Sale of the bonds is declared assured on the basis of traffic counts recently conducted by the highway department, which indicate that enough vehicles will use the bridge to make it a sound investment. The board of consulting engineers which formally passed on the technical, financial and economic angles of the project, comprises Charles E. Andrew of San Francisco, designer of the San Francisco bay bridge; R. B. McMinn of Portland, Ore., bridge engineer, U. S. Bureau of Public Roads, Admiral Luther E. Gregory, formerly head of the naval bureau of yards and docks and R. H. Thompson former Seattle city engineer. Cost of the pontoon bridge itself is placed at $3,240,000, while a bridge of steel deck spans and concrete piers would cost $13,000,000, and a suspension bridge would cost $15,187,000, according to the board. The soft lake bottom would require piers deeper than those for the San Francisco bay bridge, which set a world record for depth.

PWA recently announced a grant of $1,552,550 for construction of a $3,000,000 bridge across Lake Washington at Seward Park in Seattle, several miles south of the location now proposed. This project has been dropped and it is hoped that the grant can now be transferred to the new bridge project.

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Largest Surety Bond Issued for Grand River

What is believed to be the largest surety bond ever issued in the United States—$9,322,960—was signed by representatives of more than 20 bonding companies at Oklahoma City, July 6, when the bond was made to guarantee the labor and material costs on the Grand River Dam Authority project at Vinita. Representatives of the bonding companies said the present largest surety bond in the United States is that for Boulder Dam, $5,000,000.

An additional surety bond for half the $9,322,960 will also be issued by the same companies to guarantee that the dam will be completed. The bonds will be issued on the Massman Construction Co., Kansas City, Mo., low bidders on the dam construction work. Oklahoma law requires that the bond must be made within the state and that the material bond must be 100 per cent of the contract price.

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Aqueduct Wage Rate Upheld by Court

The New York State Court of Appeals has finally set aside a taxpayers' injunction suit seeking to halt the award of contracts for construction of New York City's Delaware Aqueduct. A temporary injunction (*ENR*, Apr. 28, 1938, p. 607) was granted last April by the Brooklyn Supreme Court, was later reversed by the Appellate Division, and is finally disposed of by the action of the Court of Appeals.

The taxpayers' suit, brought by Mayo L. French, claimed that the wage rates established for the project were higher than those actually prevailing in the region traversed by the water supply tunnel. French claimed that the city comptroller had fixed the rate without making a personal investigation.

Half U.S.H.A. Money Is Earmarked

Sixty-nine million is set aside for seventeen more communities in housing program

Total funds earmarked by the U. S. Housing Authority for cities participating in the $800,000,000 federal slum clearance and low rent housing program reached $427,299,000 on July 1 when Nathan Straus, U.S.H.A. Administrator, earmarked an additional $68,925,000 for seventeen local housing authorities.

Major earmarkings in the new group were $25,000,000 for the city of Los Angeles, $15,000,000 for the District of Columbia, and $9,000,000 for Atlanta. No money had previously been earmarked for these communities.

New York amendment

Public housing advocates in New York State were encouraged on July 7 when the committee on housing of the New York State Constitutional Convention, now in session approved an amendment which would authorize the state to incur a debt of $300,000,000 for housing and slum clearance.

In addition, the amendment would permit municipalities in the state to borrow as much as 2 per cent of their assessed valuation outside of their constitutional debt limits for housing purposes. However, in cases where a local community receives money from the $300,000,000 state fund, this amount would have to be included in the 2 per cent. Municipalities also would be permitted to make loans or tax exemptions for local housing authorities.

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Rogers, Ark., Must Improve Sewage Plant Operation

Following a nuisance suit brought by property owners living in the vicinity of the Rogers, Ark. sewage disposal plant, the city of Rogers has been ordered by Chancellor Lee Seamster to operate its sewage disposal plant in a manner not to contaminate property. Complaints of improper functioning of the disposal plant began three years ago. Mayor E. V. Vinson of Rogers testified that failure of the plant to operate properly resulted from the use of the sewer for refuse from a large vinegar plant. Chancellor Seamster announced that if a correction is not made within 30 days, the court will order the Benton county sheriff to stop operation of the plant. The plant serves a large part of Rogers.

Rio Grande Rectification Is Completed

The Rio Grande moved into a wholly canalized channel between El Paso and Box Canyon on June 29, with the completion of the San Elizario Island section. With completion of this section, the $6,000,000 rectification project, started in 1934, has been completed with the exception of some floodway leveling.

The rectification program has reduced the previous river distance of 155 miles from El Paso down to Box-Canyon to 88 miles. The work involved construction of 176 miles of leeves, of which 45 miles were built by Mexico.

The International Boundary Commission, which carried out the rectification program, is now concentrating on the canalization of the river above El Paso to the Caballo Dam.

L. M. Lawson is the American commissioner on the International Boundary Commission, and J. Pedrero Cordova the Mexican commissioner. C. M. Ainsworth is consulting engineer for the U. S. section and J. C. Bustamente for the Mexican section.

CALENDAR OF MEETINGS

NATIONAL SOCIETIES

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Hotel Utah, Salt Lake City, July 20-22.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Pacific Coast convention, Portland, Aug. 9-12.

LOCAL AND REGIONAL

WESTERN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual convention, Reno, Nev., Aug. 10–13.

AMERICAN WATER WORKS ASSOCIATION, Central States Section, Hotel Windsor, Wheeling, W. Va., Aug. 17-19.

NEW ENGLAND WATER WORKS ASSOCIATION, annual convention, Hotel Statler, Boston, Sept. 13-16.

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Short Course

A COURSE for operators of water and sewage treatment plants will be held at the University of Maryland, College Park, Md., Sept. 12-14. The course will be given in cooperation with the Maryland-Delaware Water and Sewerage Association, the Maryland State Department of Health, and the American Water Works Association, Four States Section. Advanced work will be provided for those who have attended previous courses.

Philadelphia Ordered To Treat Sewage

State water board orders city to build sewage treatment plant to halt river pollution

Acting under the terms of the LaRue bill passed last year by the Pennsylvania legislature, the state sanitary water board on July 6 moved to compel Philadelphia to build a sewage disposal system to prevent further pollution of the Delaware and Schuylkill Rivers. The board referred the Philadelphia case to the state department of justice with a request to take court action against the city.

According to chief engineer John H. Neeson of the city department of engineering and surveys, a thoroughgoing treatment program would cost about $64,000,000; David W. Robinson, executive secretary of the Interstate Commission on the Delaware River Basin, however, stated at hearings on the action that necessary primary treatment of domestic sewage could be obtained for about $25,000,000. He said that 80 per cent of domestic sewage discharged into the Delaware River is now untreated.

Pollution bill

The LaRue bill (*ENR*, July 8, 1937, p. 47) gives the state water board broad powers to order any municipality now discharging sewage to stop doing so at any time without regard to any previous permit under which it may have been discharging sewage. A municipality directed by the board to cease pollution must construct treatment plants of a design satisfactory to the board. If there is no money available for such construction, and bonds cannot be sold without exceeding the municipality's debt limit, or if voters refuse to approve the bond issue, the municipality must issue non-debt revenue bonds secured by rentals from sewer users.

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Four States Sign Pact To Control Delaware

Formal ratification by administrative agencies of New York, New Jersey, Pennsylvania and Delaware of a reciprocal agreement for the correction and control of pollution of Delaware River waters has been announced by the Interstate Commission on the Delaware River Basin. To control future pollution and correct existing pollution, the signatory states have agreed to enact "adequate legislation," if necessary.

Road Investigation Held In Ohio, Not Illinois

There is no investigation under way in Illinois of irregularities in the purchasing and contracting divisions of the state highway department, as was stated in a news account on page 7 of last week's issue. The news item referred to the Ohio state highway department and the word Illinois was inadvertently inserted instead of Ohio.

Latest development in the Ohio situation is the filing of a third taxpayers' suit by Don L. Littell, Columbus attorney. The suit charges that the state highway department and the Mansfield Asphalt Paving Co. prepared "high and unreasonable" estimates on highway projects in Crawford and Seneca Counties. Damages of $61,623 are asked from the main defendants, who are state highway director John J. Jaster, Jr.; assistant highway director, George M. Anderson; deputy director of highway maintenance, Fred L. Biechele, and divisional director, Ivan Ault. Three bonding companies are also sued for $10,000 each.

OBITUARY

GEORGE V. RHINES, 62, vice-president of the Toledo architectural and engineering firm of Mills, Rhines, Bellman & Nordhoff, died in Toledo on June 29. Rhines graduated from the School of Architecture of Columbia University in 1893 and immediately went with the Mills firm, then known as Mills & Wachter, as an architectural draftsman. Specializing in industrial and structural engineering, Rhines designed the structural elements of the Ohio Bank building, the Commodore Perry Hotel, the Willys Overland plants and numerous other structures in the Toledo area.

C. A. COUSINEAU, 38, an engineer in the employ of the Quebec Stream Commission, was drowned in the headwaters of the Ottawa River June 25 in a canoe upset while he was working on an investigation of dam sites in the Abitibi district of northwestern Quebec. Cousineau was a graduate of McGill University.

CHARLES J. FILION, 52, WPA zone engineer at Port Angeles, Wash., committed suicide there July 2.

DAVID I. MCDOWELL, Seattle civil engineer, died there June 26 at the age of 52. McDowell, a resident of Seattle since 1914, served for a time in the city engineer's office there.

EDGAR A. MCKENNA, for 20 years a civil engineer with the New York Central R.R., died in Brooklyn July 2. McKenna was a past president of the New York State Society of Professional Engineers.

HARRY N. STROH, 72, formerly a construction engineer for the Ohio State Highway Department, died June 24 in Parma, Ohio.

PARKER DAM IN OPERATION

PARKER DAM, which will regulate the Colorado River and form the head pool for the Colorado River Aqueduct, was placed in operation July 1 when the second of the two 29-ft. diversion tunnels was closed.

The illustration shows a section of steel tunnel lining form being lowered into place to become part of a 44-ft. high steel arch dam used in closing off the second diversion tunnel.

Quebec Highway Minister Is Dismissed

Francois Leduc, minister of highways for the province of Quebec, was dismissed from his office by E. L. Patenaude, lieutenant governor, July 7, following his refusal to resign his office as requested by Premier Maurice Duplessis, head of the provincial government. Premier Duplessis was appointed to the vacant post. The Premier now holds the posts of Attorney General, Minister of Lands and Forests, and Minister of Highways. No specific explanation of the Premier's action was made.

Leduc, a civil engineer, is a graduate of l'Ecole Polytechnique, Montreal; he was recently elected as a member of Council of the Corporation of Professional Engineers of Quebec. He was the first engineer ever to hold the highways portfolio in the Quebec Government.

LABOR NOTES

HOUSE RECONSTRUCTION and repair work in the Montreal and Three Rivers districts, Quebec, costing less than $2,000 has been exempted, by an order of the provincial government, from the prevailing collective labor agreements in the construction industry. Objections to the order have been filed by the Montreal Builders Exchange, asserting that neither the builders exchange nor the Montreal building trades unions were consulted.

CONTINUATION of the present wage scales and the present six-hour day is incorporated in a contract signed last week between the Master Builders Association of Seattle, composed largely of house builders, and the Seattle Building Trades Council. The six-hour day is made mandatory except when the union cannot furnish sufficient men to the employers, in which case an adjustment board is empowered to permit an eight-hour day at straight time. The contract runs until Jan. 1, 1940.

The Seattle Branch of the Associated General Contractors has not yet settled its disagreement with the union over the six-hour day; an early agreement is expected, however. Since a strike of several weeks last March, the six-hour day has been tentatively in force.

ST. LOUIS hoisting and portable engineers on city projects went on strike July 5 seeking increases from $1.50 and $1.75 to $1.75 and $2 an hour.

A STRIKE at Bartlett Dam on the Verde river in Arizona was averted early this month when the contractors, Barrett & Hilp and Macco, agreed temporarily to an arbitrators' award of a 12½ cent hourly increase in carpenter's wages, bringing them up to $1.12½, the scale set by the Arizona Industrial Commission under the state's minimum wage law.

The difficulty, according to the arbitration committee, arose from delay on the part of the Bureau of Reclamation in establishing the Arizona wage scale at Bartlett dam. The prevailing wage scale for carpenters in Arizona has been increased 20 per cent since the Bartlett contract was signed. A provision in the construction contract provides that the government will absorb increases in the prevailing wage scale which occur subsequent to signing of the contract. By the present agreement, the contractors have agreed to grant the increase pending settlement of the case by the bureau.

COMMENT AND DISCUSSION

Readers' opinions on matters that concern the engineer

Curve Spirals

Sir: Your editorial of June 23 on the subject of spirals for highway curves is read with great interest. The mention of dissimilarity between railroad curves and highway curves is appropriate.

Theoretically the spiral transition curve is a curve of constantly changing radius between the tangent and the curve proper. The degree of curvature of this spiral varies from zero at the tangent to that of the curve proper where the two meet. It is thus necessary for the driver of a vehicle to constantly change the rate of curvature of his vehicle in driving over the curve, and in the event he is traveling at the usual present-day high rate of speed he must also constantly change the speed of his vehicle until the constant-radius curve is reached. Would it not lessen effort and increase safety for the driver to adjust his rate of curvature and speed in one operation at the beginning of the curve? These are a few of the reasons why the writer has always advocated simple curves for highways and has insisted upon their construction in all work under his direct supervision.

As a further means of promoting highway safety another departure from tradition is suggested. Highway curve warning signs usually read "Curve", "Slow Curve", "Dangerous Curve", or "Turn," etc. and the line of demarkation between these several terms is vague. As a more desirable alternate I suggest signs reading "20-mile curve, 30-mile curve, etc.", depending on the safe rate of speed at which any modern vehicle may travel the given curve. This definite warning will permit the driver to adjust his vehicle speed to that at which he may safely travel the curve.

The installation of such signs should be only after careful investigation in each case to insure reliability of the posted information, thus retaining the respect of motorists for these signs. The cost involved in changing present signs to this new system would be small compared with the present damage caused by vehicles skidding on curves due to excessive speed. It seems that this method of highway signing would go a long way toward bringing our existing highways up to the standards demanded in new highway construction, where design is based upon definite controlling speeds over long stretches of road.

EARL C. MYERS,
Hastings, Neb., June 28, 1938

Aerial Tramways

Sir: The article on Conchas Dam that appeared in the June 9, 1938 issue, is very interesting, yet in reading the description of the concrete plant, on page 811, this writer received the impression that the use of an aerial tramway for such service is considered as quite unusual and remarkable in that the contractor should place full confidence in that particular unit. This impression is heightened by the editorial comment on page 837 of the June 16, 1938 issue, wherein the aerial tramway is stressed and appears to excite wonder in the minds of the editors that an aerial tramway could be such an efficient and reliable tool.

The writer respectfully takes exception to such a view, because of the countless enterprises in all fields of mining, construction, quarry, and even agricultural pursuits throughout the world where entire operations are dependent upon the day in and day out performance of aerial tramways.

Among the long list of large construction works on which aerial tramways have been used in much the same manner as the unit at the Conchas Dam, the writer recalls the Gilboa Dam, (1922); Remmel Dam in Arkansas, (1923); Coolidge Dam in Arizona, (1925); Pardee Dam in California, (1926); and more recently the Pine Canyon Dam, California, Madden Dam at the Panama Canal, the Seminoe Dam, O'Shaughnessy Dam, and Marshall Ford Dam.

In mining fields it is common practice to use aerial tramways as the connecting link between mine and preparation plant, where a shutdown of the aerial tramway would mean the shutdown of all work.

Scores of tramways have been in operation for 10 to 20 years, with a daily working period of the full twenty-four hours in many instances. The dependability of these units is so well established that it is quite unusual to find provision made for any appreciable storage at either end of the tramway.

Perhaps the writer's long acquaintance with aerial tramways and their dependability has engendered an impression from your articles different from other readers, yet he feels called upon to offer these comments in support of a time tried and proven form of conveying equipment.

GILBERT M. KILCARR,
Vice-President, Aerial Tramway Division
Interstate Equipment Corporation
New York, N. Y., June 30, 1938

A Standard Product

Sir: In reviewing the June 2 issue I came upon the interesting item on p. 790 under the heading "From Field and Office."

It isn't that we feel particularly slighted in the lack of the mention of the name of LeTourneau, but that the description of the LeTourneau Crane sounds very much as if this tractor appliance is a makeshift affair.

All joking aside, the "goose neck boom on rubber tires" is a standard piece of LeTourneau equipment and one of which we are very proud. It has done an excellent job for a great many contractors all over the country, because it serves many purposes such as crane, pile driver and wrecker; it may even be used with a small orange-peel bucket.

GEORGE R. HUFFMAN,
Advertising Manager
R. G. LeTourneau, Inc.
Peoria, Ill., June 11, 1938

Ship Impact

Due to a printshop error the formulas which appeared under the above title (*ENR* April 28, 1938) in a letter by B. A. Johnson of the Harvey A. Hanson Const. Co., Chicago, were published incorrectly. The correct formulas follow:

$$\Delta = \frac{L_1^2 v}{6EI}\sqrt{\frac{3WEI}{L_1 gN\left[1+\left(\frac{L_1}{L_2}\right)^3+\left(\frac{L_1}{L_3}\right)^3+\cdots\right]}}$$

$$M_n = v\left(\frac{L_1}{L_n}\right)^2\sqrt{\frac{3WEI}{L_1 gN\left[1+\left(\frac{L_1}{L_2}\right)^3+\left(\frac{L_1}{L_3}\right)^3+\cdots\right]}}$$

ENGINEERING NEWS-RECORD

Copyright 1938, by McGraw-Hill Publishing Company, Inc.
Volume 121, Number 2

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Editorial Offices at 330 West 42nd Street, New York

JULY 14, 1938

AFTER THE PURGE TRIAL of the three TVA directors at the White House a few months ago it was a foregone conclusion that the result would ultimately have to stand a court test. Now that Arthur E. Morgan has sued to challenge the President's dismissal, this test is in prospect, though the verdict may not be known for a year or two. The test is important less because of the question of personalities involved than because of its bearing on sound and orderly administration of major public development undertakings. Large-scale pioneer planning such as that involved in the Tennessee Valley enterprise requires above all a reasoned approach and the harmonious action of a number of able minds. The threat of economic disruption through either personal dictation or political bargaining is too great to be contemplated. And as both these risks were involved in the TVA's procedure from the early announcement of fiat power rates to the Berry claim scandal and its sequel, the Morgan dismissal, a clear decision in the present suit will afford protection to all future national development undertakings.

Torsional Strength

IN his argument before the American Society for Testing Materials in favor of the torsion test as a quality test for metals Dr. Albert Sauveur made out a strong and appealing case. Whether the case is sufficiently strong to overcome the simplicity and informative value of the tension test appears doubtful, however. When a bar is twisted only the outer edges experience maximum stress, and the behavior of the whole bar is an indefinite composite of different stress conditions. Obviously the influence of stress will not be sharply defined. On the other hand, since the torsion test develops a large amount of plastic deformability, it may perhaps provide a broader characterization of quality than can a simpler test. It is worth remembering that the bend test, which also involves varying stresses, long was the structural engineer's best indicator of strength and toughness. There are similar possibilities in a torsion test, especially because it is likely to expose local defects such as seams more clearly than will the tension test. But if a blanket test for steel quality is desired it may be simpler and better to return to the cold bend test as a dependable workbench check.

Better Bridge Inspection

REMARKABLE PROGRESS has been made in the past few years in systematizing bridge inspection. Advance is most noticeable in those state highway departments that inherited hundreds of old bridges from the counties, which required inventory and thereafter careful watching and repair. But other state highway departments and cities and railroads have likewise assigned new values to bridge inspection. It is now a major division of work whose procedures deserve the same critical study that is accorded design and construction practices. Recording and filing of inspection data has received much attention. What to record, what to look for and how to find it—in short, how to inspect, has received less consideration, presumably on the assumption that the field procedure is elementary to a seasoned bridge inspector. The assumption is no doubt justified, though it should not rule out attempts at improvement. Oregon, as outlined in an article in this issue, has given attention both to systematizing its data collection and to developing improved technique of inspection. Those simple tasks whose methods of accomplishment seem most obvious are often highly responsive to attempts at improvement. Bridge inspection may be one of those. If so, its relation to public safety warrants exploring all possible improvements.

Dredging a National Boundary

COMPLETION of the remarkable scheme projected some years ago by the International Boundary Commissions of Mexico and the United States to fix the course of the Rio Grande in the long stretch between El Paso and Fort Quitman places on record a case unique in the history of boundary lines. The rectification did not adopt and fix the existing thread of the river, nor did it return it to the abandoned windings which actually formed the international boundary prior to rectification: instead it marked out a new boundary line, placed the river there, and interchanged land parcels so that completion of the job leaves the United States wholly north of the river and Mexico wholly south. A new boundary, in short, was scooped out by the dredges. But it is important to remember that it would hardly have been possible to form such a new boundary and hold it against shifting by scour and flood unless the flow of the river had previously been controlled by reservoirs above. Elephant Butte, and its recent supplement, the Caballo dam, bring about enough equalization of flow to protect the rectified channel. Thus, in little more than thirty years the upper Rio Grande's

waters have been conserved by storage, utilized to irrigate some hundreds of thousands of acres, and finally regulated as a new boundary to the equal advantage of the neighbor republics.

Engineering Skill

DETAILS of a flexible concrete riprap for which bids are being called by the engineers of Kingsley Dam in Nebraska are given in this issue. A month ago (June 2, p. 787) a type of ceramic riprap also developed for the same dam was described in these pages. Both types of riprap find their origin in the need for a substitute for rock in a region far removed from an ample source of suitable natural material. The reinforced concrete design here described is notable for the skill embodied in a product that combines both stability and flexibility. Regardless of the type finally adopted, the thinking reflected in these studies stands as an example of the resourceful planning characteristic of efficient engineering service.

Express-Road Experiment

EXPRESS ROADS continue to develop and claim public attention. Recent months brought definite discussion of an express road from Washington to New York and another from Albany to Buffalo, and Congress showed interest in pretentious plans for national express-road systems. No better demonstration of the demand for express roads can be found than the Governor Nice highway; but Pennsylvania's South Penn and Connecticut's Merritt Parkway are also timely examples, in their respective fields of use.

Certain important problems remain unsolved in connection with express-road planning, however. The Governor Nice Highway brings some of them to view, at the same time that it attracts interest as the latest full-scale experiment on the critical question of need for roadside isolation.

Maryland's new road is tangible proof of the extensive demand for road modernization: An old and badly congested road, too throttled by roadside development to permit of satisfactory improvement, had to be bypassed if a trunk route capable of serving modern traffic was to be provided. Through service rather than local service was at issue. The highway is designed to give capacity, safety, speed and freedom from traffic interruption in a degree not possible on most long-established roads, and therefore in general requiring new routes. And finally the Maryland road demonstrates the acceptance won by dual road construction for main trunk routes.

As an experiment on the need for freeway construction the Governor Nice road deserves country-wide attention. It is held by many that express roads must be planned on the freeway principle, that service to local traffic and roadside use is incompatible with service to through traffic. But the new Maryland highway has been built without physical separation from the abutting property. In very few years its service experience will show how well the efficiency of a trunk road can be maintained against roadside encroachment.

Everyday Concrete

WHEN FIGURES SHOW that concrete on the everyday job varies 1:3 in strength, or from less than half the expected strength to 60 per cent above, it is plain that general concrete practice is far from equaling the precision and excellence of the best. Miles N. Clair last week reported such figures for a dozen or more moderate-size jobs built in the New England territory. They may be taken as representative of everyday concrete practice throughout the country, for there is no reason to believe that practice elsewhere is materially better, and some California data indicate that job strengths there vary about as much as in New England.

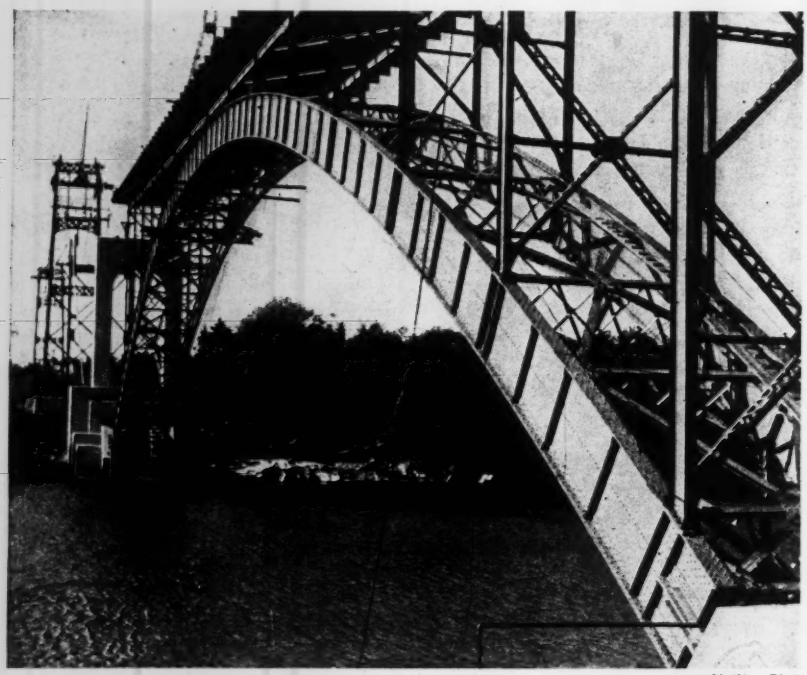
It is not news to learn the everyday job differs from the large job, on which thorough control is practiced. But it is news that the difference is so extreme—or, to put it plainly, that everyday concrete is so poor. What this means may be judged from the fact that the larger part of all concrete work is of the everyday or small-job kind. In practical application, the term "concrete" means everyday concrete.

For this reason the figures mentioned claim serious consideration by the designer. Unless they can be shown to be wholly unrepresentative they mean that the general designer must fit his working stresses and structure proportions to the nonuniformity and strength deficiency that characterize the everyday job rather than to the conditions of the scientifically controlled job.

The observed variation in concrete strength also points the way to the most immediate opportunity for advance in concrete practice: Making ordinary concrete equal to the best. And this means first of all developing field tests that will give a quick and dependable check on concrete quality.

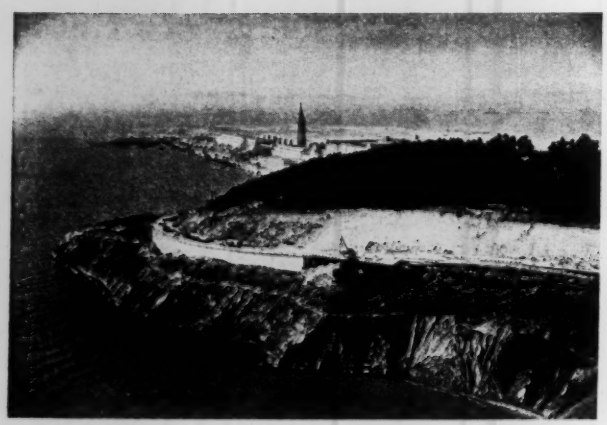
In brief, the attention of the test and research men should now be directed to everyday concrete instead of to laboratory and field-control concrete. The brilliant results of concrete research to date appear to have done little to correct the variability and unreliability of everyday concrete. Improvement of this condition constitutes the leading problem of the concrete art today.

PICTURES IN THE NEWS



Mathieu Photo

THOUSAND ISLAND BRIDGE. *This 348-ft. arch between Constance and Georgina Island is part of the Thousand Islands bridge project being constructed jointly by the United States and Canada. The towers of one of the suspension bridges on the project are in the background. The picture was taken the middle of June.*



MOTORISTS' ROUTE TO THE SAN FRANCISCO FAIR. *This gash on the face of Yerba Buena Island is the location of the Bay Bridge connection to Treasure Island. Motorists crossing the suspension spans from San Francisco go through the tunnel, turn right and encircle the island, passing over Bay Bridge traffic as shown.*

FIG. 1. MARYLAND'S DUAL ROAD HAS LONG TANGENTS AND FLAT CURVES

Notable Dual Road Completed

NATHAN L. SMITH

Chief Engineer, Maryland State Roads Commission, Baltimore, Md.

A four-lane divided highway from Baltimore to Havre de Grace starts Maryland's part of a dual highway to Wilmington, Del.

BETWEEN Baltimore and Havre de Grace, Maryland, U. S. Route 40 has for many years followed a tortuous path (Fig. 2), with sharp horizontal and vertical curves, narrow bridges, inadequate sight distances and other features that tend to create traffic hazards. Between these same cities, the Pennsylvania and the Baltimore & Ohio railroads have their main lines from Philadelphia to Washington. Adjacent to these transportation lines to the southeast lies the Chesapeake Bay, and from this body of water, a number of tidal streams extend for several miles inland. To locate a modern highway along this route between railway and water occupancy of the land was a problem which faced the engineers of the Maryland State Roads Commission.

New location most economic

The original studies contemplated a modernization of the highway as it existed and it was proposed to install a pavement 30 ft. wide within a 60-ft. right-of-way, utilizing as much of the existing surfacing as possible. This proposal offered several compelling objections, which are listed as follows:

(1) It was found that the proposed revamping to a 30-ft. surface would involve right of way damages substantially as great as those which would be faced if a four-lane highway were constructed on a 70- or 80-ft. right-of-way.

(2) Traffic counts taken along the road at three locations between Baltimore and Havre de Grace showed an average daily movement for 1930 to 1935 of from 5,300 to 7,300 vehicles. On a modern two-lane highway this load would not have been sufficient to cause unusual congestion, but about 10 per cent of the movement consisted of buses and trucks of over 3 tons capacity. This, together with the limited sight distances which made it impossible for the faster vehicles to pass, and the steep grades which reduced the truck speed to below 20 mi. per hour combined to make the road one of the most congested in the state. Peak traffic occurred during the spring and fall race meets at Havre de Grace, and on the Labor Day week-end, when as high as 22,000 vehicles were clocked on a single day. It was, therefore, evident that only a four-lane highway would answer the needs of the traffic.

(3) A few years previously, the commission had completed the widening of U. S. Route No. 1 from Baltimore to Washington from two lanes to four, utilizing the existing pavement as a base for almost the entire distance. After completion a study of the costs showed that for the same expenditure, a highway of modern design could have been built on a new location. The accident record on this road has been very high and each year some additional betterment has been necessary to keep the highway up to its standards.

(4) Further studies showed that to secure the necessary 80-ft. right-of-way for four lanes along the existing route, with so many homes, filling stations and other business establishments existing, would involve an expenditure far beyond justification.

After a number of surveys and plans had been prepared and many conferences held with the federal officials, an entirely new location was selected between the two railroads with a crossing over the Baltimore

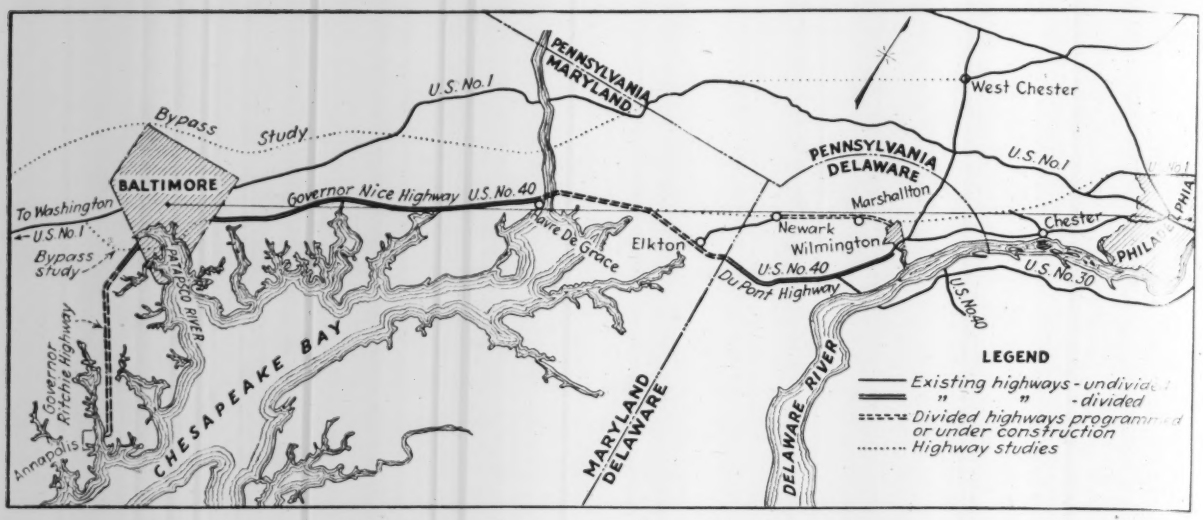


Fig. 2. Location of Maryland's dual highway and its present and planned traffic connections.

& Ohio R.R. track to provide entry into Baltimore at the point where the original highway was located. Fig. 2 shows the relative locations of the old and new highways, and the water area.

A right-of-way with a minimum width of 150 ft. was decided upon and the commission set about acquiring title to the land. Major difficulties occurred adjacent to Baltimore and in the town of Aberdeen. On the Baltimore end, in addition to several improved lots that had to be taken, the right-of-way passed through deposits of valuable brick clay and other natural resources. In Aberdeen, along the selected location, a total of 30 residences and other buildings had to be removed or destroyed.

Maryland does not have a legal right to post bond and go ahead with the physical construction, but must complete negotiations for properties before they can be occupied. In many cases, condemnation proceedings had to be resorted to, and each entailed much additional searching of titles, surveying, plotting and legal proceedings. As options were secured at various points along the line, the grading contractors were notified to go ahead, but nearly three years elapsed from the signing of the first option until the last obstruction to paving was removed. The cost of the rights-of-way, in spite of the fact that much of the area traversed was of little value, reached the total of $640,000.

Since several hundred feet of swamp areas were crossed and the excavation needed to fill and raise these areas called for deep cuts, it was decided to let separate contracts for the grading and bridges between Baltimore and Aberdeen, and allow the embankment ample time for settlement. The first contract for grading was awarded on June 18, 1934, and was followed in rapid succession by six other grading contracts. In spite of the splendid cooperation of all contractors, this grading work was not completed until July, 1936, right-of-way hold-ups being the main cause of the delay. Under these contracts, about 1,920,000 cu.yd. of excavation were removed and over 9,000 cu.yd. of concrete were used on the smaller drainage structures.

The procedure, in connection with the swamp areas, consisted of first removing the vegetable mat, which, at some points was 4 ft. deep. This was done by blasting with 50 per cent nitroglycerine, which is fast-acting, and has a shattering effect. The charges consisted of one or more sticks, spaced 18 in. apart along rows of 5 ft. apart, parallel to the center line. It was necessary to cap only the first charge in each row, the rest being fired by propagation. This charge broke and removed the vegetable mat and also tended to liquefy the underlying material. The size of each shot was determined by the surrounding culture; in open country there were usually 100 ft. long and 20 ft. wider than the distance from outside to outside of the shoulders.

After the vegetable mat was removed, the fill was brought forward in the shape of a wedge, the point being as long and narrow as the hauling equipment permitted. The fill was carried well above the finished grade of the road, the depth being determined from soundings taken across the entire cross-section by special drilling equipment to determine the depth of the mud. While the varying density of the mud and the compactibility of the fill material affect each location, the fill was usually placed to a depth above the finished grade equivalent to two-thirds the depth of the mud.

Explosive charges were then placed mid-way between the bottom of the fill and the hard bottom, the size and spacing of the charges being determined by trial shots. A slow-heaving explosive, 40 per cent gelatine, was used and the fill thrown from 10 to 12 ft. in the air, it having been found that greater charges broke up the fill and the effect of its impact upon dropping back was lost. Heavier charges were also placed along each edge of the fill and fired about 1/5 sec. ahead of the underfill charge, thus creating relief ditches to provide a space for the displaced underfill mud. After the explosion, the fill was permitted to remain untouched for several weeks, preferably until after a rain, to allow the voids to be filled and a general settlement of the material to occur. A bulldozer was then used to smooth over the fill and make any necessary adjustments to bring it to the proper grade and cross-section. The accompanying sections (Fig. 3) indicate the work stages.

Besides the swamp fills, the presence of so many arms of the Chesapeake Bay necessitated the construction of numerous pipe and box culverts and other small drainage structures, and of 13 bridges having spans of more than 25 ft. including one structure carrying the highway over the Baltimore & Ohio R.R. tracks at Golden Ring. The largest stream crossed was Big Gunpowder Falls.

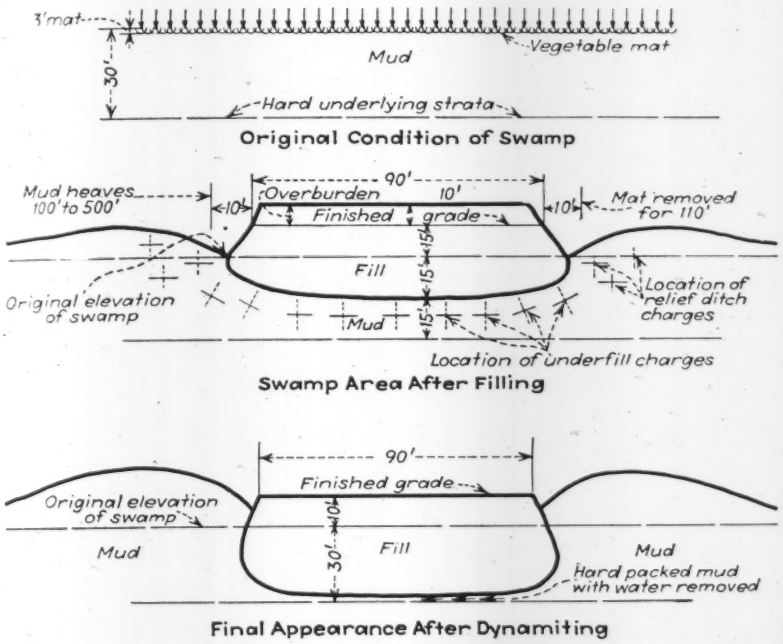


Fig. 3. **The settlement of swamp fills was a major grading problem successfully solved by blasting, as schematically illustrated.**

A three-span structure with a total length of 190 ft. was required here. The bridges of smaller span lengths are concrete girders and those having spans in excess of 50 ft. are steel beams with concrete deck. The smaller structures have a roadway width of 80 ft. so that the headwalls are 5 ft. outside the pavement edges. The largest structures, of which there are five, consist of two separate bridges to take care of the dual highway providing a 30-ft. clear roadway for each lane. When the original estimates were prepared for these five structures, it was found that there would be a saving of about $100,000 if the dual type bridge was adopted. All of these bridges are designed for the heaviest standard truck loading used in highway bridge design.

Fig. 4 shows the typical dual-road cross-section consisting of two lanes with concrete surfacing 20 ft. wide, separated by a 30-ft. parkway, and having a 10-ft. shoulder area along the outside of the pavement on each side. If the need for additional traffic facilities should occur, an additional 10-ft. lane can be paved on the outside of the present pavement in the areas now occupied by the shoulders, and sufficient space still be available for other 10-ft. shoulders with 20 ft. additional for sidewalks and drainage facilities. Between Aberdeen and Havre de Grace, where no bad foundation conditions were encountered, and where the topography was conductive to the design, a revision was made in the plan, and a parkway 50 ft. wide was provided. The commission very definitely feels that 50 ft. is the desirable width for separation between lanes of traffic, as it allows greater freedom for left-turn movement and provides added space for vehicles awaiting an opportunity to enter the other lane of the highway. However, the nature of the topography on the major portion of the location, particularly the swampy areas, forced the restriction of the 30-ft. width.

Provision is made for the surface drainage by sloping the pavement toward the inside, except on grades less than 0.5 per cent, where the slope is toward the outside. The 30-ft. park areas are crowned to slope toward the inside edge of the pavement. Surface water is retained on the pavement by an inside raised edge, or lip curb 3 in. high and 9 in. on the diagonal. This water goes to especially designed inlets with connections to a storm water drain running through the parkway area to available outlets.

Where the 50-ft. parkway was indictated, the raised edge was omitted from the inside of the pavement and the roadway crowned to slope in both directions from the center joint. The inner 30 ft. of the parkway is crowned and drains to a flow line 10 ft. from the inner edge of each paved lane. Should additional lanes of pavement be needed in the future, they can be provided on the inside of the present pavements, and will be of the raised-edge construction.

The concrete surfacing was designed and constructed in 10-ft. lanes, 9 in. thick along each edge, and 7 in. in the center. Tie bars on 4-ft. centers were used between the two slabs, and in the construction of the 10-ft.

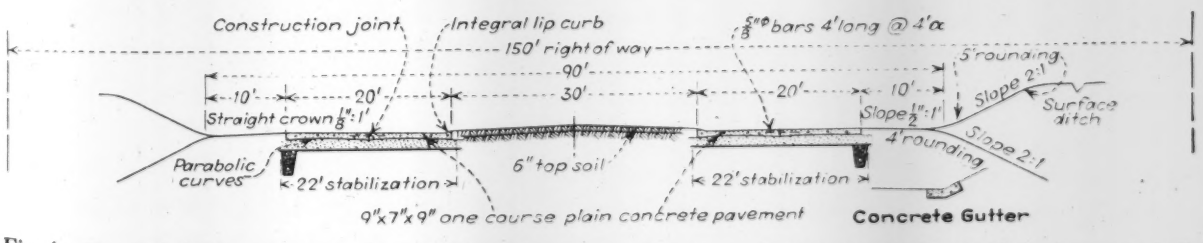


Fig. 4. **The dual roadway structure where a 30-ft. parkway separation was used; where practicable a 50-ft. parkway was built as preferable in dual-road design.**

Fig. 5. Long tangents and rolling grades characterize Maryland's 27-mi. dual road from Baltimore to Havre de Grace, which was opened to traffic in January.

lanes contraction joints were spaced 30 ft. apart, with the expansion joints every 90 ft.

The slope on both cuts and fills were designed with a ratio of 1 on 2; however, all of the waste excavation was used in uniformly flattening the fill areas or in widening the shoulders, and all the material excavated to provide the frost bed was likewise utilized in this manner. This widening has greatly increased the safety of the highway, gives the motorist an added feeling of security and has effected a reduction of about 25 per cent in the estimated amount of guard-fence required. This guard fence consists of wood posts with two wire cables and is located at the outer edge of the 10-ft. shoulder.

Paved connections, or cross-overs, between the dual slabs were made at intersecting public roads and at intervals ranging from 1,500 to 2,500 ft. in sections where there were no such intersections. Through Aberdeen, cross-overs were provided at each street intersection.

There are but 10 curves throughout the entire distance. The maximum degree of curvature on the project is 2 deg. 30 min. The minimum sight distance is 700 ft. and the maximum grade 6 per cent; about 2 mi. have grades ranging from 4 to 6 per cent, 5 mi. from 2 to 4 per cent, and the remaining 20 mi., less than 2 per cent.

Water problems

The grading disclosed the fact that through many of the cuts, the subgrade was below the water-table formed at the junction of the sand-gravel stratum with the underlying stratum of clay, and in other instances it was found that the entire cut was of clay. In both cases a bad subgrade condition resulted, which made stabilization and subsurface drainage imperative if excessive maintenance costs on the pavement were to be avoided.

For stabilization, it was decided to place a 6-in. layer of sand over the clay subgrade, and to work it into the clay by a scarifier and farm disk harrow; this method was discarded when it was found that a uniform mixture could not be obtained. The subgrade was then excavated 1 ft. and a frost-bed 1 ft. deep was constructed of sand. To provide drainage for this frost-bed, a 4-in. tile underdrain was constructed parallel and adjacent to the outside edges. Tests to determine the moisture content in the frost-bed, after a three-day rainy spell, showed that where underdrain has been constructed a 4 per cent moisture content existed, while where no underdrain was placed, this moisture content was 19 per cent.

To prevent erosion of the shoulders, through the cut sections on heavy grades, cement rubble masonry gutters were constructed, with the rebut paved 18 in. along the slope. In cuts where there was seepage through the slope, berm ditches were dug parallel and adjacent to the top of the slope. In one cut near Belcamp, a large amount of seepage was encountered and an attempt was made to control the water by a ditch at the toe of the slope. This method was ineffective and to eliminate costly maintenance, the condition was corrected by the installation of perforated corrugated metal pipe, placed in the original ditch location and backfilled with gravel.

Considerable difficulty was experienced in keeping the forms for the concrete pavement to proper line and grade in the sand frost-bed; 30-in. pins were used, but the results were not entirely satisfactory. It was found that run-of-bank sand gravel made a very satisfactory bed for the pavement, providing rapid drainage and having small volume change when wet and being easily compacted and sufficiently stable to support the forms. On portions of the road, this was used instead of the sand.

In quite a few instances, low-bearing-value soils were encountered in pipe-culvert foundations. This condition was corrected by constructing a timber grillage of sufficient width to provide the necessary bearing area to carry the load. One failure of the grillage occurred, due to water running under and undermining it; to prevent a recurrence, sheet piling was driven across the front of the grillage at the intake end of the culvert.

Quantities and costs

In addition to the grading and concrete masonry listed above, which were placed under the grading con-

tracts, the following quantities entered into the construction of the highway:

Excavation, immediately in advance of paving—480,000 cu.yd.
Sand and sand-gravel for subgrade stabilization—162,000 tons.
Concrete in smaller drainage structures —3,000 cu.yd.
Concrete surfacing—672,000 sq.yd.
Wire rope guard fence—50,000 lin. ft.
Culvert pipe—29,500 lin. ft.
Tile for stone underdrains—66,600 lin. ft.

The total cost of the project is as follows:

Rights-of-way	$640,000
Grading and drainage	994,000
Fill acceleration	96,000
Bridges under separate contracts	410,000
Paving, including frost-bed	2,004,000
Topsoil	52,000
Total	$4,196,000

Future extension planned

The present eastern terminus of the dual highway is at the west side of the bridge over the Pennsylvania R.R. near the Havre de Grace race track. From this point, Route 40 passes through Havre de Grace and across the Susquehanna River on the double deck bridge. An 18-ft. roadway extends from the river to the Delaware State Line, a distance of about 18 mi. directly through the main business streets of Perryville, Northeast, and Elkton. It passes under the Pennsylvania R.R. tracks at Perryville, under the same railroad at Northeast, and over the tracks again at Bacon Hill. All of these grade separations are on sharp, dangerous curves. A fourth overhead crossing occurs just to the west of Elkton.

It is proposed to extend the dual highway around the built-up area of Havre de Grace, and across the Susquehanna on a new and adequate bridge. The improvement will then continue between the two railroads to Elkton where another bridge will be built over the Pennsylvania R.R. for west-bound traffic, utilizing the existing bridge for east-bound. Elkton will be bypassed and connection made at the state line with the dual highway south from Wilmington which Delaware has recently placed in service.

Direction

The road as described has been named the Governor Nice Highway. The work has been carried out under two successive state roads commissions; for the first H. D. Williar, Jr., was chief engineer and for the second and present commission the writer is chief engineer.

Double Cone Precipitators To Be Employed at Minneapolis

Tanks for new water softening plant designed to serve as combination mixing, coagulating and settling basins for lime treatment process

THE new lime treatment type softening plant at Minneapolis will use the double cone type precipitators developed by Charles H. Spaulding, general superintendent of the Springfield, Ill., water department (*ENR*, June 3, 1937, p. 804). Design features of the new plant which includes 12 precipitators, a low service pumping station, chemical house, carbonation chambers, sludge concentrators and disposal beds, were described by J. A. Jensen, engineer of the Minneapolis water department, at the recent meeting of the American Water Works Association in New Orleans. The following is an abstract of that paper.

The Minneapolis water supply comes from the Mississippi River and it is filtered at two rapid sand type plants, each with a capacity of about 80 m.g.d. The water has an average hardness of 175 p.p.m. and proposals for softening the supply have been under consideration for a number of years. The softening problem is one of moderating the calcium and magnesium carbonate content and under the form of treatment adopted it is proposed to reduce this to about 75 p.p.m. For this purpose, lime treatment will be used which, incidentally, will also assist in removing color from the water. Color difficulties are particularly noticeable in the early summer months and the average color ranges from 14 to 101 p.p.m., it is proposed to maintain the color at not more than 10 p.p.m.

Following experimental work on softening for nearly four years, using models of conventional rectangular basins, cylindrical clarifiers and cone type precipitators, the following conclusions were drawn:

1. Rapid settlement of sludge by sedimentation separates the water from the lime before full reaction takes place. This is shown by returned sludge furthering the reaction and increasing softening.

2. Deposited sludge subjects the included organic matter to deterioration. If returned, it may impart taste and odor to the treated water.

3. In conventional tanks, at least three to four hours' retention is necessary.

4. Retained suspended sludge in regulated degree of compensation is highly effective in its action upon the calcium and magnesium constituents of this water.

5. A high degree of stabilization and clarification is attained in one and one-half hours or less of retention and contact time in detained suspended sludge.

To obtain best results, based on the above conclusions, it was decided to employ the precipitator devised by Spaulding for use at the Springfield, Ill., plant. The precipitator is a combination mixing, coagulating and settling tank. It consists of an inside truncated cone with the

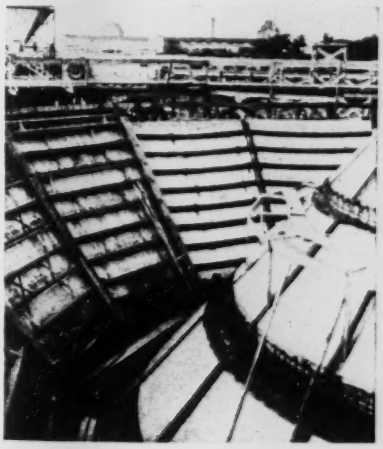


Fig. 1. Formwork for the double cone precipitators.

small end at the top where raw water is admitted; inside the cone is a stirring mechanism. Outside of the cone is another truncated cone with the large end at the top. The annular V-shaped compartment thus formed by the inner and outer cones constitutes a sedimentation compartment. Between the periphery of the lower part of the interior cone and the lower part of the exterior cone is a slot through which the treated water rises more or less vertically. A sludge cloud (formed by precipitated calcium carbonate) forms immediately above this slot; this cloud seems to be effective in promoting precipitation and clarification in the precipitator.

The precipitator makes use of continually forming fresh sludge within a brief period of time. The regulated compensation and periodic drawing off required obviates the possibility of deterioration of organic matter or algae in the sludge thus formed.

Design features

The 12 precipitators will each have a nominal capacity of 10 m.g.d. The diameter of the outer cone at the top is 85 ft., and at the bottom of the section, 58 ft. The bottom of the inner cone has a diameter of 60 ft. and the top is a truncated section 16 ft. in diameter. Below the base of the inner cone and integral with the outer cone is a cylindrical chamber 58 ft. in diameter and about 4 ft. in depth within which a 40-ft. horizontal wheel with extended arms will rotate at regulated speed. Between the conic sections is a 4-ft. annular opening through which the water will rise from the agitation chamber into the outer cone.

The conduit leading to each cone has a system of openings to spread the water and obviate a jet current. The water moves downward with an ever decreasing velocity and the rotating wheel equalizes eddies and cross currents and maintains suspension of sludge particles in the agitation chamber at the bottom. The rise of water between the annular openings carries the sludge to the plane of equilibrium which is self-selecting according to the varying conditions.

This plane is a distinct division between turbid and clear water. The clear water at the top rising at the normal rate of 2 in. per minute overflows a circular weir and enters the collector conduit which has a common outlet into the carbonation chamber.

The sludge drawn off from the precipitators will be pumped through a thickener or sludge concentrator. The concentrated sludge will be pumped to prepared sand beds or lagoons with sub-surface drainage for drying.

The total cost of the plant is estimated at $2,500,000.

Sulphur Pipe and Linings

New technique makes possible the fabrication of sulphur-composition pipe and linings

SULPHUR, because of its inertness towards water, certain electrolytes and acids, has been used for years as a jointing and sealing compound in the construction of floors, sewers, acid tanks, etc. Recently it has been applied to the fabrication of pipe and the lining of steel pipes. The technique employed, similar to that used in the production of centrifugally cast iron pipe, was described by Isaac Bencowitz of the Texas Gulf Sulphur Co. at recent meeting of the American Chemical Society.

The fabricating apparatus consists of a rotating jacketed mold and a feeding mechanism. The mold is started cold and as it revolves at about 1,000 r.p.m., a small quantity of molten sulphur is fed into it. This cools and sets to form a skin on the mold. This skin is coated with fine coke and the combination facilitates the subsequent removal of the finished pipe. The mold is next charged with a given quantity of coarse aggregate, followed immediately by a predetermined quantity of molten sulphur mixed with aggregate.

After sufficient rotation to secure good compaction of the material the mold is stopped and heated with steam. The preliminary skin of sulphur cast in the mold melts and permits the easy withdrawal of the finished pipe. In Table I is shown the composition and characteristics of sulphur pipe.

Sulphur-lined pipe

The following method of fabrication is used in applying a sulphur lining to steel pipe. The pipe interior is first coated with a bituminous material and then a steam-heated core of the proper size is centered in the pipe. Following this a mixture consisting of molten sulphur and aggregate is poured into the annualar space. After the mixture has solidified, the core is removed, leaving a pipe with a homogeneous interior coating of sulphur.

Sulphur pipes are said to be unaffected by changes in temperature, and are resistant to many corrosive liquids. Pipes made of sulphur combined with an aggregate were reported to have been exposed to extremely corrosive "bleed water", containing salt, sulfides, sulfates, etc., for more than two years without signs of deterioration. It was also stated that sulphur-lined steel pipe has been used for the conveyance of salt brine and after three and one-half years of service are still in good condition. In such service unlined steel pipes have been known to fail in four months.

COMPOSITION AND CHARACTERISTICS OF SULPHUR PIPE

Weight per lin. ft.	Percent Composition by Weight					Strength Hydraulic Pressure lb./sq.in.	Tensile Strength lb./sq.in.	Density
	Sulphur	Sand	Coke	Gravel	Asbestos			
34	83				17	95	152	1.77
35	66	16	7		11	85	136	1.87
35	57	23	11		9	65	104	1.87
38	35			60	5	75	120	2.23

Safeguarding Bridges By Inspection

E. G. RICKETTS

Bridge Testing Engineer, Oregon State Highway Department

Oregon decreases upkeep and insures public safety by finding and correcting small defects before they become serious

BRIDGES constitute an important item in the maintenance of Oregon's highways because the state owns 2,422 bridges or an average of one every 2.8 mi. over the entire state highway system. Maintenance cost is relatively high because of the large number of old bridges inherited with county road systems. Some of these are obsolete and shoulded be replaced, but until funds for replacement are available the obligation for safe maintenance rests on the highway department. This means frequent inspections to discover any progressive deterioration.

Recently-built bridges, though modern in design, also are subject to damage and deterioration—by traffic wear, floods, high water and climatic conditions conducive to decay, disintegration and corrosion. Thus, for new bridges as well as for old, it was considered desirable to establish a systematic plan for regular inspection of all bridges on the state highway system. Such a plan makes it possible to operate the system as a whole in a more effective and economical manner. The plan has been in effect long enough to have been systematized and made both simple and satisfactory. Essentials of the plan, particularly methods of inspection and making records, are therefore set forth here.

A regular bridge inspection program serves several useful purposes: It is a precautionary measure because inspections can be made often enough to insure discovery of weaknesses before accidents occur. The character and extent of necessary renewals or improvements can be determined in advance, so that an annual budget may be prepared and funds authorized. This allows for comparison of alternate methods, preparation of plans or sketches, and scheduling work in the order of urgency. It also makes it possible to assemble necessary equipment and order materials in advance at a time that will take advantage of the best market prices. State bridge crews can be maintained the year round so as to be always available in emergencies, can be routed with the minimum of lost motion, and can be kept at strategic points during times of high water and floods. Finally, routine inspection provides a service record of the bridges valuable in determining the life expectancy of different types under various climatic and traffic conditions. The inspections also are instrumental in discovering design defects and correlating needed replacement with the construction program.

WEST SIDE PACIFIC HIGHWAY #3
U. S. Route #99W

Loc.No.	Acct.No.	Name & Office No.	Description
10.12	152-01	Fanno Creek # 264	3-20', 1-10' F.T.spans on conc. reds. 23' Rdy. bet. 5' sidewalk curbs. 4x12 deck. Asph. w.s. 9 lines, 6x19 stringers. Built 1929.
12.98	152-02	Tualatin River	4-40' RCDG spans, 1-150' steel deck truss, 5-40' RCDG spans. 27' Rdy. bet. 5' sidewalk curbs. Conc deck. No w.s. Built 1929. P.M. top sidewalk #1L & 11R. Stamped _____. Elevation_____.

Fig. 1. Typical log notes of initial bridge inspection.

Bridge inspection program

The routine bridge inspection program consists of two parts: an original inspection, and later supplementary inspections at stated intervals. The original inspection obtains all measurements not available from office plans and also gathers data for a bridge log, illustrated in Fig. 1. The log includes a description of each bridge, the type, date of construction, width of roadway, number and length of spans (listed in the order of the highway mileage) and a mile-post location number which identifies the bridge by its distance from the zero mileage point. Copies of the log sheets, bound together, are convenient for both field and office use.

The sample log sheet shows account numbers for each bridge, which are used for tabulating all expense charges. Numbers under the name of the bridge indicate the job record file, which contains all preliminary and design data for the bridge before it was built as well as the construction records. This job record is available of course, only for those structures designed and built by the state highway department.

The results of supplementary inspections are recorded on the form shown in Fig. 2, which was designed to speed routine inspections without sacrificing thoroughness. The form contains four elements: (1) The heading, which identifies the structure and contains information taken from the bridge log. (2) Observations, which constitute the main part of the report, including check lists of items relative to the waterway and bridge type. Thus the one form is useful in inspecting bridges of all types or a single bridge made up of several types. By listing all import-

ant items to be checked in the inspection, danger of oversight is avoided. (3) A space for remarks is provided for items that need explanation or further investigation. Finally, (4) under the heading "Maintenance and Betterment Recommendations" are listed specific work items to be included in the budget for the succeeding year. If emergency repairs are required they are given special authorizations for immediate attention.

No absolute rules can be laid down for inspection of a structure, but the following instructions have been compiled as an aid to systematic bridge inspection.

Waterway

Conditions in the streambed should be noted as to (1) adequacy of channel afforded by the existing structure; (2) risk of scour that may endanger the footings; and (3) presence of obstructions, such as drift logs, stumps, or old piers, that may be diverting the current so as to cause undermining of the footings. Also note any undergrowth or obstructions that can be removed to increase the adequacy of the waterway or, in the case of timber structures, to lessen the fire hazard. Lastly, note whether streambank protection is necessary to keep the channel properly confined and thus to avoid endangering the bridge foundations or the end fills.

Piers and abutments

Timber Foundations—Piles supporting timber bridges should be inspected carefully at the ground line, as this is where decay first sets in. A ¾-in. hexagonal steel bar about 4 ft. long, with one end sharpened to a long tapering point and the other end provided with a chisel face, is a very useful tool in such examinations. It can be jabbed into a pile to disclose deterioration not apparent on the surface and to determine the extent of sap rot. Piles in which the diameter of sound material has been reduced to 6 in. or less should be marked with yellow keel for replacement.

Replacement may be made by erecting a post on the cut-off pile, properly spliced at the joint, but this may not be done when two or more unsound piles in the same bent are *adjacent*. In such cases all piles in the bent should be cut off and replaced by a frame bent on the cut-off piles, if they are sound; otherwise on cedar mud-sills or concrete pedestals, depending on the condition and remaining life expectancy of the structure. Sills, bottoms of posts, and mud sills for frame bents should be similarly tested.

Steel Tubular Piers—Steel tubular piers should be carefully examined for corrosion in rivets or bolt heads connecting the cylindrical sections. (The filling material in such steel cylinders is usually inferior and without strength in itself).

Also note whether there has been appreciable movement of the tubes due to impact of heavy loads on the structure; if so, additional footings or bracing may be needed. Note whether the steel tubes are out of plumb and if so whether this is due to undermining, to lack of proper bracing or to inadequate support below. Examine base of tubes for exposed piling caused by scour.

Concrete Substructures—The pier shafts should be examined for damage from drift or ice. Examine exposed footings for rock pockets due to improper placement of concrete. Note extent of any undermining. Look for cracks, and note whether they are caused by unequal settlement, contraction, or fill pressure. Check abutments and adequacy of wing walls. Recommend placement of riprap and rock slope protection where necessary.

Concrete structures

Culverts — Examine barrel and wing walls of culverts to find any harmful cracks due to settlement that should be grouted to prevent deterioration of the reinforcing steel. Also examine floor of barrel to note any upheaval which may cause failure of side walls due to excessive fill pressure; especially note this in culverts under high fills.

Beam-and-Slab Spans—Note condition of railing for damage by collision; sight alignment of railing for indication of settlement of the structure. On heavily traveled roads, the handrail should be kept clean in order to provide proper visibility for night driving, and if conditions warrant should be painted with a cement wash coat. Examine beams for cracks that may be due to clogged expansion joints, settlement, or fill pressure at either end of bridge. Note any surface checking in deck, railing, curbs, or sidewalks that may allow water to seep in and cause disintegration by freezing action. Any such cracks should be waterproofed to prevent corrosion of reinforcing and hence serious deterioration of the structure. An asphalt mastic wearing surface for the deck is a very successful means of waterproofing deck cracks and at the same time smoothing up the riding surface to take out any unevenness, whether from rough finishing at the time of construction or from later developments.

Steel truss spans

On steel trusses note first the general alignment of the span to see whether the end posts and top chords are straight and in line. Any buckling indicates that the structure has been overloaded. Especially note this for light construction. Kinks in any one member may have been caused by damage in shipment, in erection, or by collision; the inspector should satisfy himself that any such kinks are not due to overstress.

For all pin-connected trusses, note whether eyebars in the same member are taking equal tension. Overloading or lack of proper camber adjustment may cause one eyebar to take all the stress, leaving the others loose on the pin. Especially note this for the diagonal and hip vertical members. Observe the structure under heavy loading, and note if there is any excessive deflection or bowing in or out of the diagonal eyebar members which would indicate lack of proper counterbracing.

Some of the older structures were not designed for the heavy loading that they are now carrying, and often counterbracing should be added or some of the members should be reinforced by additional loop rods connected by turnbuckles. Note condition of end shoes and rollers to see if proper expansion is being provided for and if the rollers are free to move. Lastly, it is important to note condition of paint and observe heads of rivets or bolts in all connections. Most steel spans should be painted every four or five

Form 130-a

SUPPLEMENTARY

BRIDGE INSPECTION AND MAINTENANCE REPORT

OREGON STATE HIGHWAY COMMISSION — BRIDGE DEPARTMENT

For bridge over Tualatin River. Hwy. No. 3 Section No. 34-23 Br. Loc. No. 1298
County Washington. Mileage numbering from Portland.
General description 4-40'RCDG; 1-150' Steel deck; 5-40'RCDG Span Sheet 1 of 1
Inspection made by A.F. Smith Date 10-29-37

OBSERVATIONS

WATERWAY		PIERS AND ABUTMENTS Timber, Steel and Concrete		CONCRETE STRUCTURES AND FLOORS		STEEL CONSTRUCTION		TIMBER SPANS AND FLOORS	
Adequacy	✓	Undermining	✓	Cracking	②	Condition of paint	④	Condition of paint	—
Scour	✓	Settlement	✓	Scaling	✓	Corrosion	①	Decay	—
Obstructions	✓	Cracking	✓	Scour	✓	Joints	✓	Wear (floors)	—
Undergrowth	①	Disintegration	✓	Settlement	✓	Loose rivets	✓	Structural defects*	—
Channel shifting	✓	Decay (lumber)	—	Disintegration	✓	Camber	✓	Crushing at joints	—
Revetments	✓	Corrosion (steel)	—	Water-proofing	②	End shoes	✓	Splices	—
Other features	✓	Other defects	✓	Other defects	③	Other defects	✓	Camber	—
		Piling foundations?	Yes					Other defects	—

Make above observations for each part of structure and note with (✓) mark to indicate "OK" or "None". For items needing explanation mark with a circle with a number inserted to refer to the corresponding remark listed below. Amplify remarks with sketches on second sheet when necessary.
*Under "Structural Defects" note any tendency to warp, split, crack, etc.

REMARKS

(Use second sheet when space below is not sufficient; also, list cause of all defects such as cracking and scaling of concrete whenever possible.)

① Brush around pier #1 grown up to bottom chords of steel truss - conducive to rusting steel.
② Slight cracking apparent in sidewalk slab, due to contraction - waterproofing not required.
③ Catch basins at end of bridge clogged.
④ Paint on steel weathered and shows indication of scaling - will require only slight cleaning if repainted next year.

MAINTENANCE AND BETTERMENT RECOMMENDATIONS

ITEM	Estimated Cost Maintenance	Betterment
Top out brush around pier #1.	Patrol Maintenance	
Clean out catch basins.	"	"
Clean, spot paint and repaint steel one full coat 110 Tons @ $3.50	$385.00	

NOTE. List under maintenance and betterment recommendations all necessary channel clearing, revetments, bank protection, channel changes, stream bed pavements, riprap work, underpinning or other foundation protection, shoulder and slope protection, repairs to concrete work, painting, water-proofing, preservative treatments, repairs to roadway surfaces, repairs and renewals to timber and piling, and all other maintenance and repair work of whatever character. Fill out in duplicate and submit original to Salem Office. STATE PRINTING DEPT.

Fig. 2. **Check-list and findings that record results of routine inspection.**

Form 179-b

BRIDGE INSPECTION Report (Continued) Sheet 1 of 1

For bridge No. 1008 Over YEW CREEK (Name of water-way) County of Benton
Name and number of highway Alsea Highway No. 27 Bridge Loc. No. 27-4706
Date of ~~original~~ inspection October 1936. Inspection and report by W.R. Stretch. (Timber Insp.)

(ADDITIONAL SKETCHES, PHOTOGRAPHS AND OTHER DATA)

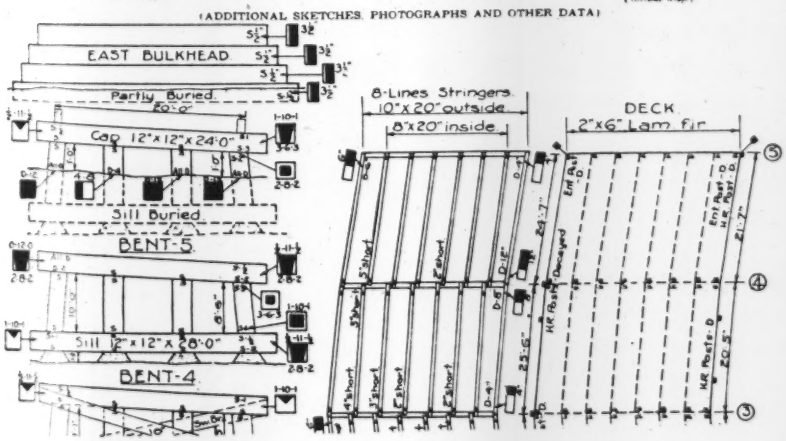


Fig. 3. **Half-page of inspection record for a timber trestle as worked up by the office staff. Dark portions of cross-sections indicate decay.**

years, except in very arid climates. Spans near the coast often require repainting every two or three years, while in Eastern Oregon the paint has remained in good condition for eight or ten years.

Timber trusses

In inspecting a timber truss, first see if it has any noticeable sag. If sag is present note whether it is due to failure of splices, improper adjustment of vertical rods, or crushing of diagonal members. Examine all splices for splitting or cracking of the shear tables. Sound the rods with a hammer to note whether each is carrying the same amount of tension, and examine condition of daps and ends of diagonal members for signs of crushing. If the structure is very old, it will be advisable to use a $\frac{3}{8}$-in. auger bit to test out the center of the top and bottom chord members for heart rot at all panel points and splices; the floorbeams at contact with bottom chords should also be bored. Decay will be found first at contact points and where rods go through timber members.

Other points to check on covered trusses will be the condition of the roof and housing. Be sure to examine truss bearings over the pier caps and the condition of caps over pier piling for crushing, and bore with auger bit where there is any doubt as to their soundness. Note whether all bolts through splices, packing blocks, and cross-bracing are tight and in good order.

Timber trestles

The substructure of timber trestles should be examined as directed under "Piers and Abutments". Caps should be examined for any crushing over the posts or piling. Decay will always be found first at bearing contacts, and a testing bar or auger bit should be used on all doubtful timbers. A thorough boring test must be made on all timbers that have been in place more than six years.

Note condition of bulkheads at each end of the bridge for decay, height, and proper retention of approach fill. Check sway and longitudinal bracing to note whether any members are broken or decayed and whether additional bracing is required.

In examining the superstructure, first go under the bridge, examine each span, and note (1) whether stringers are crushing, cracking, or splitting, (2) whether they have full bearing over the caps, and (3) whether bridging between stringers is in place. Note condition of under side of decking and see whether all bolts are properly tightened or have become loose due to shrinkage of timbers.

Second, examine deck and handrail from roadway. Especially on high bridges, sound handrail posts with testing bar at contact with felloe-guard, stringers, and railing to see that members are not badly decayed. Handrail should be kept painted for protection against decay and to provide visibility for night traffic; all decayed members must be replaced. Timber handrails require repainting about every three years.

Organization

In carrying out the work outlined in the foregoing the bridge testing engineer has working under his direct supervision a two-man timber inspection crew provided with the necessary equipment, staging and other facilities for boring all parts of a structure. Their findings are noted with the aid of sketches in an ordinary transit field book but are further worked up in the office, as shown in Fig. 3. The darkened parts of the cross-sections there shown indicate the decay found in the structure. This report serves the triple purpose of (1) indicating the parts decayed, (2) giving the necessary measurements for ordering material needed in renewals, and (3) providing a systematic record of the replacements, each item of which is completed when the authorization for repairs is returned with red-pencilled note of completion.

The maintenance engineer has the state divided into fifteen maintenance districts, each in charge of a maintenance superintendent who reports directly to his respective division engineer. In order to translate this procedure into performance, each superintendent is responsible for the inspection of the bridges in his district at least twice yearly, preferably once during high water and again during low water periods. Copies of each superintendent's report are forwarded to the bridge testing engineer, whose duty it is to check over all structures with each district superintendent annually and make such special investigations meantime as may become necessary. Subject to the approval of the bridge engineer, he is also responsible for the preparation of any necessary plans, sketches, or specifications; he outlines methods of procedure, and supervises installation of the more difficult bridge renewals and replacements. He cooperates with the maintenance engineer to effect the most satisfactory and economical performance of the work and is custodian of all bridge inspection records, recommendations and history of the renewals completed on each structure.

The staff officers are G. S. Paxson, bridge engineer, and L. N. Bishop, maintenance engineer, acting under the general direction of R. H. Baldock, state highway engineer.

Precast Concrete Riprap for Kingsley Dam

D. A. BUZZELL

Chief Hydraulic Engineer, Central Nebraska Power & Irrigation District, Hastings, Neb.

New type of reinforced concrete riprap specified as alternate for protection of dam slopes

A NEW TYPE of reinforced concrete riprap has been designed for possible use to protect the upstream face of Kingsley Dam (formerly Keystone), Nebraska. Bids on this new type of bank protection are being asked by the Central Nebraska Power and Irrigation District. Alternate bids are being taken on stone and on a ceramic riprap (*ENR* June 2, p. 787), but in case these materials prove to be uneconomical, it is desired to provide a concrete facing that will meet the peculiar requirements of the dam. The shell of the dam is to be of river gravel, and since the only available gravel contains an exceptionally high percentage of fine material, with only a trace of particles large enough to be retained on a one-inch ring, it is considered unusually important that free drainage through the riprap be secured.

The dam will be 160 ft. high and two miles long in the river valley section. The upstream slope will be 3 to 1. The 2,000,000 acre-ft. reservoir will have a maximum depth of 140 ft. and a reach of 21 miles.

It is considered essential that the dam facing be flexible enough to allow considerable unequal settlement without danger of rupture, that it offer a rough surface to prevent waves racing up too high on the freeboard, and that it be sufficiently open to provide free drainage of the fill. It is also desirable to eliminate shrinkage and temperature cracks which have often opened the way to eventual complete failures where a solid monolithic-slab facing has been used.

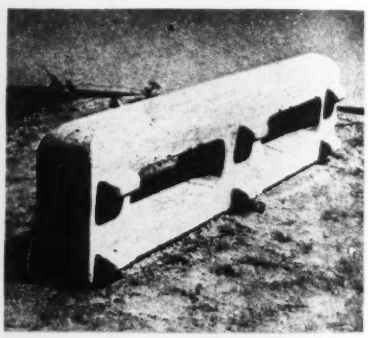


Fig. 1. Concrete block proposed for riprap at Kingsley Dam.

The accompany drawing is largely self-explanatory. Individual units of the facing are from 4½ to 6 in. thick and vary in depth from 9 in. for the lower part of the facing to 18 in. at the top. All are to be 4 ft. 6 in. long so that there will be no interruption in the continuity of the locking bars. The ½-in. round asphalt-dipped steel locking bars for the

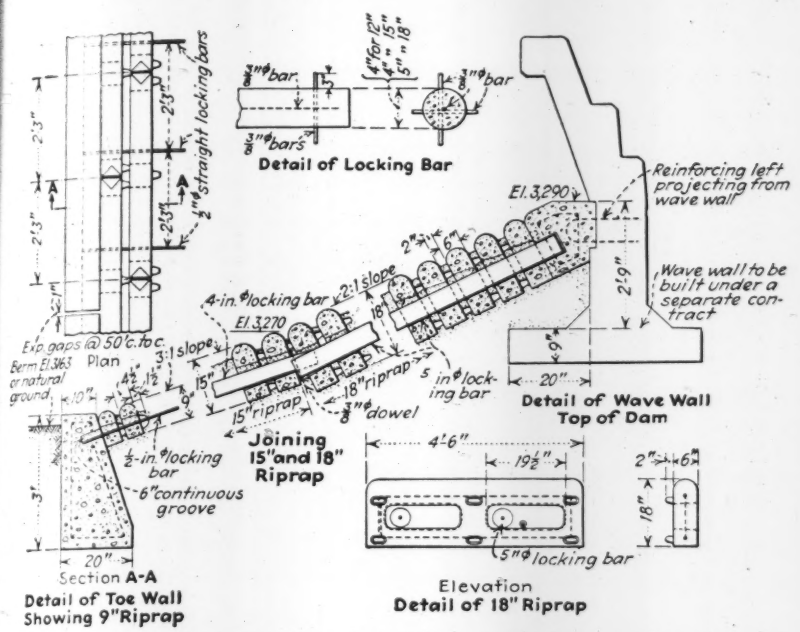

Detail of Locking Bar
Reinforcing left projecting from wave wall
Wave wall to be built under a separate contract
Detail of Wave Wall Top of Dam
Joining 15"and 18" Riprap
Detail of Toe Wall Showing 9"Riprap
Elevation
Detail of 18" Riprap

Fig. 2. **Reinforced concrete riprap designed to provide the protection of a monolithic slab and the flexibility and draining qualities of loose rock.**

lowest course are anchored in a monolithic concrete toe wall. Locking bars for the 12, 15, and 18-in. facing are of reinforced concrete. These are made circular in section so that the coarse-gravel fill between the blocks will not jam between the locking bars and the units in such a manner as to cause arching over a point of settlement. Locking bars were introduced into the design to enable any unit or zone of units subjected to severe wave or ice action to borrow stability from the surrounding mat. It was felt that this feature gave the design all of the advantages of a monolithic concrete mat without incurring the liabilities inherent in the latter design.

It will be noted that the interlocking of the units provides two points of anchorage for each one and yet that the mat as a whole is very flexible in any plane normal to the surface of the dam. A dam facing must survive not only as a whole but individually, or piece by piece. When loose stone is used, this survival depends entirely on the weight of the individual piece. When hand-placed stone is used, some bond is secured with adjacent pieces. The 18-in. concrete units proposed for this work weigh only 374 lb. each but a shearing force of 9,000 lb. would be required to dislodge one from the dam facing. This makes it, in some ways at least, equal to a 4½-ton stone.

Separation of the units by means of the integrally-cast bosses effects some economy of material but was primarily intended to insure free drainage of the fill. The spaces could have been made wider if a coarser gravel had been available. A graded gravel will be used to fill all spaces between and within the units. This will not only add to the weight and security of the mat but will act as a filter to prevent loss of fines from the dam face.

The units weigh from 150 to 374 lb. each and it is planned to skid them into place from a movable wooden runway built on the dam face above the line of placement or to transport them by means of an overhead monorail conveyor system. Only four of the smaller units, or three of the larger, are required for one square yard of riprap.

Specifications call for a 3,000-lb. vibrated concrete. It is probable that a vibrating-table type of continuous-block machine will be used to manufacture the units. Another plan under consideration would call for the casting of the units in place.

Details of this design have been submitted to a large number of contractors for comments and suggestions and most of them have signified a willingness to bid on this work.

A total of 450,000 sq. yd. of mat or 90,000 cu. yd. of concrete will be required. Nearly two years will be allowed for the completion of the mat.

The accompanying table gives the quantities of concrete, reinforcing steel and filter gravel required for the various thicknesses of mat. These quantities include the locking bars.

QUANTITIES OF MATERIAL PER SQ. YD. OF SURFACE IN CONCRETE RIPRAP

		Concrete cu.yd.	Gravel cu.yd.	Reinforcing Steel lb.	Weight of One Unit lb.
9-in.	Riprap	.149	.101	9.9	150
12-in.	Riprap	.175	.158	15.3	236
15-in.	Riprap	.238	.179	15.7	322
18-in.	Riprap	.276	.224	16.2	374

The dam is being built by the Central Nebraska Power and Irrigation District of which George E. Johnson is chief engineer and general manager.

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Arithmetical Error Does Not Void Bid

A CONTRACTOR who bid too low on a job, due to an arithmetical error by his estimator, was held not entitled to the return of his deposit when he refused to take the contract at the low figure, in a recent decision by the New York State Court of Appeals.

Ferend Co., a painting contractor, bid $16,670 on a painting job in a New York State hospital on which other bids ranged from $26,500 to $38,800. The contractor deposited $835 as a guarantee of good faith at the time of making his bid, as required. The contract was awarded to Ferend.

Five days after the bid opening, the contractor notified the state that his estimator had forgotten to double the wall area of one of two identical wings, and that if this error had not been made the bid offered would have been $24,270. The contractor sought the return of his deposit.

The Court of Claims gave judgment for the contractor but the Apellate Division reversed this decision and dismissed the claim. The Court of Appeals affirmed the decision of the Appellate Division.

New Legislation Aids Contractors On Former Federal Work

JOHN W. GASKINS

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Act just passed by Congress facilitates collection of losses under National Recovery Act

OF MORE than passing interest to many general contractors, subcontractors, and materialmen who performed government contracts during the period when the National Industrial Recovery Act was in effect will be a statute enacted during the closing hours of the last session of Congress. This statute confers jurisdiction upon the United States Court of Claims to entertain suits against the United States for the recovery of increased costs to contractors, subcontractors, materialmen and completing sureties resulting from the operations of the National Industrial Recovery Act on contracts entered into before Aug. 10, 1933.

Not first effort

The present measure is not the first effort that Congress has made to effect a reimbursement. The hardships that the National Industrial Recovery Act worked upon government contractors who had assumed their obligations on the basis of labor and material prices existing before the passage of the act but were required to fulfill those obligations under the price schedules in effect subsequent to the act, was made known to Congress soon after the Recovery Act was passed. The inequity of this situation was readily apparent and the following year Congress made an effort to restore such losses to the persons who had suffered them.

The first legislative step in this direction was an act authorizing the Comptroller General of the United States to settle such claims for additional costs as were encountered by reason of compliance, after Aug. 10, 1933, with either the codes of fair competition or the President's Reemployment Agreement. Claimants were required to file their claims with the executive departments under which they arose and the executive departments were in turn required to make recommendations to the Comptroller General, accompanied by administrative findings of fact. Final decision on all such claims lay with the General Accounting Office and there was no redress by way of appeal to the courts from the finality of such decisions.

The procedure that a contractor was obliged to follow was expensive, yet after many claimants had submitted their claims through the contracting departments the claims were either wholly or in part rejected, the rejections in a large measure resulting from the invocation of legal technicalities.

Judicial hearing

Under the present statute determination of claims is wholly divorced from administrative procedure. In its place is substituted a hearing before a judicial tribunal which for years has devoted a large amount of its time to the adjudication of issues arising between contractors and the government through the performance of government contracts. The mandate that the Court of Claims has received from Congress is to determine such questions of increased cost of performance "upon a fair and equitable basis." In addition, the act extends to claimants the same right of review as would normally exist in any case entertained by the Court of Claims under its general jurisdiction.

Another interesting phase of the statute is that it opens the door for judicial review of allowances made to those contractors who were partially successful in their efforts to obtain reimbursement under the prior statute.

The present statute also eliminates another inequitable feature that existed under the prior one. Many contractors who possessed contracts based upon price conditions existing prior to Aug. 10, 1933, had counted upon, and, but for the passage of the Recovery Act, would have received a profit in excess of 7 per cent on the cost of performing their respective contracts. The prior act contained the provision that in no event should any allowance be made to the claimants which would result in their receiving a profit in excess of 7 per cent on the cost of performing their contracts. In those instances where a higher profit would have been realized, the effect of the earlier statute was to extend only partial relief. This provision has been eliminated from the present legislation.

Statute of limitations

It is important to note that the statute of limitations now allows only six months for the institution of suits, or until Dec. 25, 1938.

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Public Works Programs Pushed in South America

MOST of the Latin American countries are continuing major public works programs during the present year, according to the Department of Commerce. Venezuela has drawn up a three year plan providing for expenditures on public works of more than $100,000,000. Part of this will be covered out of current revenues and the remainder will be financed by the issue of 20-year treasury bonds.

In Argentina, construction has begun on two new buildings to house the War and Navy Departments, one 18 stories high and the other 15 stories.

Several Latin American countries are continuing low cost housing projects for workers, and Chile, Peru, and Venezuela have built peoples' restaurants.

Seal Coats as Road Roofs

ADRIAN R. LEGAULT
Colorado State College, Fort Collins, Colo.

Rapid-curing products prove superior in parallel tests in the laboratory and on the road for roofing roads

Users of asphaltic oil in its various forms for roadbuilding are uniting to urge the coordination of laboratory tests with observations of field experience. The article that follows is primarily an account of such a comparative study. Incidentally it emphasizes the place that the lighter asphalt oils of the cutback class are assuming in surface treatment and in road-mix construction. — EDITOR

A SERIES of field and laboratory tests on six different types of bituminous material has just been completed at Colorado State College, Fort Collins, Colo., the purpose of which was to determine which material is best suited for use as a seal coat. Only a summary of procedure and results is given here. The details of the project are available in a bulletin entitled, "Seal Coats for Bituminous Surfaces."

The work was divided into two parts. The first was to apply the different materials to sections of oiled road which had begun to fail by raveling, and to select by observation the type which appeared to be best for seal coating. The second part consisted of laboratory tests to substantiate the field observations by comparing the materials as to strength, penetrating ability and other characteristics. The results of standard tests on the materials are given in Table I.

Field test procedure

The application of the materials in the field was by hand; the oil was poured from a sprinkler can and spread uniformly by brooming. Each oil was applied at the rate of about 0.2 gal. per sq.yd. A sprinkling of sand, about 5 lb. per sq.yd., was put on some sections; on other sections no covering material was used.

Table II gives the application temperature and drying time for each oil from the time the seal coat was applied until traffic could pass over it without harmful effects. The temperature when the seal coats were applied ranged from an average minimum of 55 deg. F. to an average maximum of 85 deg. over a 24-hr. period.

To determine the relative ability of the different materials to seal the surface against the entrance of water, samples of the subgrade were taken from immediately beneath the mat, and their moisture content determined after several heavy rains about 10 months after the seal coats were applied. Drainage conditions are identical for all sections. The results of tests for moisture in the subgrade are shown by Fig. 1.

What inspection showed

The surface of each section was inspected one year after the seal coats were applied and the following observations were recorded:

1. The MC-1 gave the poorest results of any material: its appearance was much the same as that of sections where no seal coat had been applied: raveling had begun again to some extent, and several hair-cracks showed in the surface.

2. The 95 road oil was wearing better than the MC-1, but the high spots were showing wear and the surface was poor from the viewpoint of nonskid properties; the sections which had been sanded were wearing better than those which had not been sanded.

3. The SC-3 was wearing well where sand had been applied; there were no cracks or signs of raveling; the surface

TABLE I.— CHARACTERISTICS OF BITUMINOUS SEALING MATERIALS SUBJECTED TO TESTS

Type	Special Seal	RC-1	RC-1	M-1C	SC-3	95 Road Oil
Specification	Manufacturer	Asphalt Inst.	Colorado	Colorado	Colorado	Colorado
Source	Wyoming	Illinois	Wyoming	Wyoming	Wyoming	Wyoming
Viscosity — Furol Secs.						
@ 77° F.	176	.....	.....	104	.....	.....
@ 122° F.	.....	132	92	.....	.....	.....
@ 140° F.	.....	.....	.....	.....	261	.....
Flash — Deg. F.	85	88	120	150	290	415
Distillation per cent off @ 374°F	12 0	11 0	5 0	.....	.....	.....
437°F	25 0	21 0	17 0	2 5	.....	.....
500°F	37 0	30 5	30 0	38 0	0 0	.....
680°F	39 5	32 5	32 5	42 0	2 0	.....
Float on original @ 122° F.	.....	.....	.....	.....	.....	236
Penetration of Dist. Residue 77°F.	36	93	102	130	.....	.....
Solubility in CCl_4 — Original	.....	.....	.....	.....	99 9	99 9
— Dist. Residue	99 6	99 5	99 9	99 9	.....	.....
Per cent 100 penetration residue	.....	.....	.....	.....	68	97
Ductility @ 77° F. 5 cm/min						
100 penetration residue	.....	.....	.....	.....	110+	110+
distillation residue	110+	110+	110+	110+	.....	.....
Ductility @ 39.2° F., 5 cm/min						
100 penetration residue	.....	.....	.....	.....	7 4	7 0
distillation residue	0	.....	8 6	11 0	.....	.....

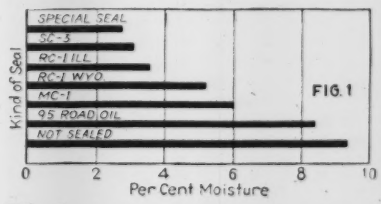


Fig. 1. Moisture percentages found in sub-base under various seal coats after 10-months wear.

TABLE II — DEPTHS OF PENETRATION FOR THE DIFFERENT MATERIALS

Type of Oil	Quantity Applied Gal. per Sq. Yd.	Depth Penetration in Inches
Special seal	0.2 and 0.4	0.15 and 0.26
Mc-1	0.2 and 0.4	0.15 and 0.24
RC-1 Wyoming	0.2 and 0.4	0.15 and 0.22
SC-3	0.2 and 0.4	0.15 and 0.22
RC-1 Illinois	0.2 and 0.4	0.09 and 0.19

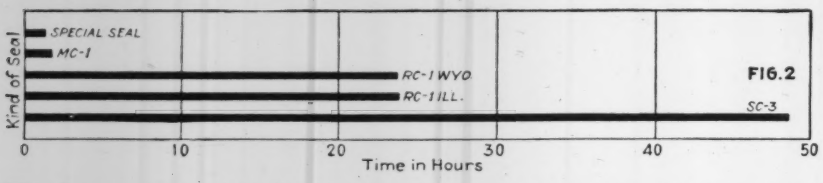


Fig. 2. Time required for the penetration of various seals applied at the rate of 0.4 gal. per sq.yd.

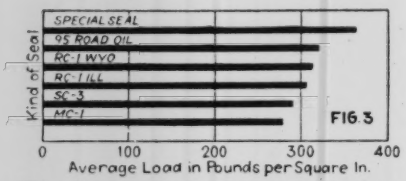


Fig. 3. Relative bonding strength of seals as shown by pull required to part two cast iron disks.

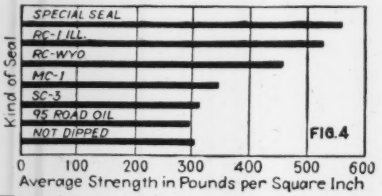


Fig. 4. Compressive strength of seal-penetrated briquets after curing one month.

was entirely smooth, with no nonskid qualities. Where no sand had been used the results were similar to those given by the MC-1.

4. The Illinois RC-1 gave good results insofar as wearing was concerned. The chief criticism here was the lack of nonskid qualities, although the surface was better in this respect than that given by either the sanded SC-3 or the 95 road oil.

5. The Wyoming RC-1 and the special seal gave similar results. These surfaces were wearing well and had excellent nonskid qualities. The oils had penetrated so that the roughness of the original surface was preserved, and yet sufficient surface bond had been supplied to stop raveling. These two oils gave better results than any of the others on the basis of both nonskid characteristics and wearing qualities of the surface.

Conclusions from field tests

Results of the field tests showed: (1) that a seal coat of any of the materials was beneficial in preventing raveling and in waterproofing the surface, and (2) that a heavier material such as the 96 road oil, which forms a blanket covering but penetrates very little, does not give as good results as a material in the general class of rapid-curing cutbacks which penetrates the surface layer of the mat, thereby strengthening it but not covering the original surface. The nonskid qualities of the surface produced by the application of a seal-coat material and the strength imparted to the original surface are of as much importance in determining the desirability of that material for sealing as is the more commonly considered property, mat waterproofing.

In these tests the materials which penetrated well left the roughened surface of the original mat exposed. The result was a surface with excellent nonskid qualities. The materials which did not penetrate gave a smooth surface. An application of stone chips would have been an improvement in such cases, but even then there is the possibility of skidding owing to the seal slipping on the original surface, particularly in warm weather. The material which penetrates the mat will strengthen it in proportion to the strength of the asphalt which is thus carried into the mat. The material which does not penetrate, however, will add no strength regardless of the properties of the asphalt in it.

TABLE III — APPLICATION TEMPERATURE AND DRYING TIME

Type of Oil	Application Temperature Deg. G	Approximate Drying Time, Hr.
Wyoming RC-1	120	24 to 36
Special Seal	100	4 to 12
Illinois RC-1	120	24 to 36
MC-1	120	2 to 6
SC-3	180	48 to 72
95 Road Oil	400	48 to 84

Laboratory studies

The field tests showed the oils which penetrated well and supplied a good bond to be superior to the others. Accordingly, laboratory tests were made to compare the oils as to penetrating properties and strength of the asphalt in the materials.

For the penetration tests a mix of standard sand and SC-3 oil was used. The sand was pulverized in a ball mill, sieved and recombined to give the desired grading. A seal coat of each material was applied to samples of the mix. After the oil had penetrated, the surface layer of the sample was lifted off and the average depth of penetration measured. Results of the penetration tests are recorded in Table III.

Fig. 2 shows the variation in time required for complete penetration when the oils were applied at the rate of 0.4 gal. per sq.yd. No data are shown for the 95 road oil because its penetration was so slight as to be negligible. The results of the penetration tests show a greater depth for the cutbacks, as well as a much more rapid penetration. Rapid penetration is a decided advantage because of the shorter curing period necessary and because it is possible to apply the material which penetrates rapidly in sufficient quantity without waste due to oil running off the surface.

The bonding strength of the asphalt in the different oils was compared by determining the force necessary to pull two cast-iron disks apart when bonded together by a thin film of asphalt. The asphalt was obtained by heating the oils until the residue had a penetration of 20 to 25. Results of these bonding tests are shown in Fig. 3.

Tests for compressive strength were made on briquets of natural aggregate and SC-3 oil. The briquets were immersed in the seal-coat oils, removed immediately, and allowed to cure for 1 month before they were tested. The results of the tests are shown in Fig. 4.

Test on the asphalt in the different materials showed that the bonding strength of the asphalt does vary with the oil. The materials containing the strongest asphalt showed the best results in the field with the exception of the 95 road oil. Its lack of penetration in the field tests explains this apparent discrepancy.

The compression tests show that a seal-coat oil does strengthen the surfaces if it penetrates. The degree to which the surface is strengthened is dependent upon the depth of penetration and the strength of the asphalt in the seal-coat oil.

Attention is directed to the fact that the term seal-coat as used means a surface treatment which penetrates and seals the existing surface without adding to its thickness. This treatment is not to be confused with the type in which a heavy asphaltic material is applied and covered with stone chips, thus blanketing the original surface as well as adding to the thickness of the mat.

Lateral Resistance of Buildings

A. FLORIS
Los Angeles, Calif.

Theory based upon observed earthquake failures requires assumption of independent column action in each story if floors are rigid

IT HAS BEEN OBSERVED repeatedly during earthquakes and hurricanes that the columns of multiple-story buildings are damaged while the floor beams remain intact. Evidently, this is due to the fact that the floors of these buildings act as rigid bodies, with the flexible columns fixed at both ends. In the presence of stiff concrete floors, therefore, the usual complicated analysis of buildings, assumed to consist of multiple-story frames, does not correspond to the realities.

If all columns in a story are of equal height, the lateral force acting at each rigid floor can be distributed to the columns in proportion to their moments of inertia, so that through several stories each column can be investigated separately.

Basis of theory

Owing to the rigidity of the floors of the two-story building, (Fig. 1) the moments M_{II} and M_I of the column (Fig. 2) must be applied at these points in order to keep the tangents to the curve of the deflected column vertical. In other words, the work done by these moments must be a minimum. Consequently, the method of least work will be applied. In this case each column acts as a cantilever, (Fig. 3), which moves laterally in such a way that the tangent to the elastic curve of the column at each floor remains vertical. This is the condition of fixity shown in Fig. 1.

Denoting with M_o the moment of the free cantilever, (Fig. 4), produced by the distributed external column forces P_2 and P_1, the actual moments at the second and first stories will be, respectively

$$\left.\begin{aligned} M_2 &= M_0 - M_{II} \\ M_1 &= M_0 - M_{II} - M_I \end{aligned}\right\} \quad (1)$$

Under these conditions and by means of the method of least work, the following elastic equations are obtained

$$\left.\begin{aligned} k_1h_1M_I + k_1h_1M_{II} &= A \\ k_1h_1M_I + (k_1h_1+k_2h_2)M_{II} &= A + k_2P_2\frac{h_2^2}{2} \end{aligned}\right\} \quad (2)$$

in which

$$A = k_1[(P_1+P_2)h_1 + 2P_2h_2]\frac{h_1}{2}$$

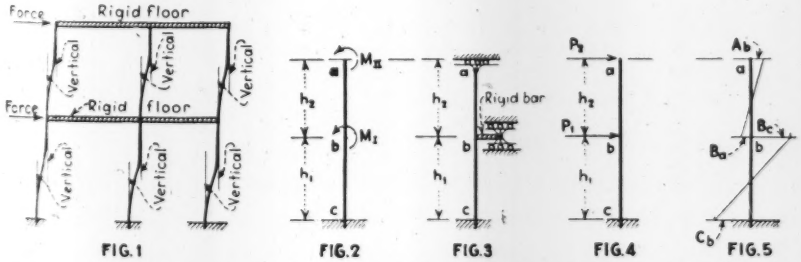
and

$$k_1 = \frac{I}{I_1}, \quad k_2 = \frac{I}{I_2},$$

where I_1 and I_2 the moment of inertia of the first and second story column, respectively and I an arbitrary constant.

Assuming, as an example, $P_2 = 1.5$ kips, $P_1 = 3.0$ kips, $h_2 = 10.0$ ft, $h_1 = 12.0$ ft, $k_2 = 1.25$ and $k_1 = 1.50$ then Eq (2) will be

$$\begin{aligned} 18.0\,M_I + 18.0\,M_{II} &= 756.0 \\ 18.0\,M_I + 30.5\,M_{II} &= 849.75 \end{aligned}$$



Column moments resulting from lateral forces on a building with rigid floors.

from which

$M_I = 34.51$ kip ft. and $M_{II} = 7.50$ kip ft.

Substituting these values in Eq (1) the moments at the column ends (Fig. 5) are obtained

$$\begin{aligned} A_b &= -7.50 \text{ kip ft.} \\ B_a &= 1.5 \times 10.0 - 7.50 = +7.50 \text{ kip ft.} \end{aligned}$$

and

$$\begin{aligned} B_c &= 1.5 \times 10.0 - 7.50 - 34.51 = -27.01 \text{ kip ft.} \\ C_b &= 1.5 \times 22.0 + 3.0 \times 12.0 - 7.50 - 34.51 = +26.99 \text{ kip ft.} \end{aligned}$$

Solving the same problem but with $k_1 = 3.75$ of the first story column, the moments will be

$M_I = 34.51$ kip ft. and $M_{II} = 7.50$ kip ft.

If the columns in a story are treated independently of the action of the columns in the other story, the moments above and below each rigid floor are, as it is well known,

$$\begin{aligned} A_b &= -1.5 \times \frac{10.0}{2} = -7.50 \text{ kip ft.} \\ B_a &= +7.50 \text{ kip ft.} \end{aligned}$$

and

$$\begin{aligned} B_c &= -(1.5+3.0)\frac{12.0}{2} = -27.00 \text{ kip ft.} \\ C_b &= +27.00 \text{ kip ft.} \end{aligned}$$

Comparing these values with those obtained previously, it is readily seen, that the agreement is very close. It could be complete if more decimal places were taken into account.

Conclusion

Thus, if the floors of a building are rigid, the adjacent stories have no influence upon the bending of the columns in a given story. Therefore, the method of analysis, which is based on the independent column action in each story can be used without hesitation. The proof may appear obvious, but to the writer's knowledge, this independence of column action has not been demonstrated to date. The possible objection that absolute column fixity cannot be realized in practice is answered by the fact that the similar assumption of joint rigidity is generally accepted in the analysis of frames.

The proof can be extended to cover any number of stories. The number of the elastic equations thus obtained is then equal to the number of stories.

Developments in Engineering Materials

A.S.T.M. meeting brings specifications up to date and records the fruits of recent research in the field of engineering materials

INDUSTRIAL COOPERATION of an old and tried kind functioned efficiently in Atlantic City last week at the forty-first annual meeting of the American Society for Testing Materials. And out of committee rooms and ballrooms turned into lecture halls came the annual crop of new specifications and research results in the field of engineering materials, as producers, consumers and laboratory specialists pooled their knowledge, agreed and compromised. With 1150 in attendance at the 200 committee meetings and 17 meeting sessions throughout the five days, the convention was the equal, in every way, of any of its predecessors.

A symposium on impact was a feature of the program, and important developments were recorded in concrete, fatigue of metals, corrosion of iron and steel, soils testing, iron research and alloys. This report focuses attention on the specifications, tests and research that are of particular significance to the construction industry.

What and why of impact

A group of papers on the subject of impact testing was among the important contributions of the convention. Since a similar symposium was held in 1922, at which impact test machines and test specimens were discussed, much progress has been made. As Prof. M. F. Sayre (Union College), chairman of the session expressed it, "Even the theory of impact has changed so that now impact is not only concerned with velocity effects but with determining the cause and existence of brittleness in materials." The papers presented were divided between those devoted to the practical use of the impact test and to those recording the latest developments in theory.

That impact testing has been adopted widely as an aid to design was made clear in a paper by Sam Tour, vice-president, Lucius Pitkin, Inc., New York City. That many of the most useful tests have no relation to the so-called standardized tests was made equally clear. The paper, in fact, was a plea for more utility or non-standard impact testing when this will produce the knowledge of brittleness or toughness that is sought. Examples were cited of useful "non-standard tests" on fiber board, wood, concrete, stone, enamel, tire chains, gear teeth, pipe, and railroad rails. Both H. F. Moore (University of Illinois) and L. B. Tuckerman (Bureau of Standards), authorities on scientific standardized impact testing, concurred in Mr. Tour's opinion of the value of non-standard utility tests.

Tractors were revealed as a beneficiary of the impact test in a paper by G. C. Riegel and F. F. Vaughn (Caterpillar Tractor Co.) This company has found the notched-bar impact test of particular utility, a Charpy specimen being used for ferrous materials having low energy-absorption values and a sharp-notch Izod specimen for those which break with a high absorption of energy. By means of these tests it has been possible to determine the reliability of the heat treatment of gear and crawler steels and thus to reject poor steels before they get into the field.

As a part of a paper on the impact testing of the molded phenol plastics used in telephones, Robert Burns and Walter W. Werring (Bell Telephone Laboratories) presented a remarkable slow motion picture (2000 exposures per second) which revealed how plastics break under the action of a pendulum-type impact machine. By subjecting the specimens to polarized light, the moving picture camera recorded the gyrations of the strain lines in the specimens, thus giving a complete picture of what happens in an impact test.

Still another practical use of the impact test—to determine the weldability of various steels—was described by Walter H. Bruckner (University of Illinois). By proper heat treatment known as a "weld quench," a sample of the steel to be studied is produced, having the same hardness, grain size and microstructure that previously has been found to exist adjacent to a weld bead laid down on the steel. From the treated bars a specimen is then prepared with a Charpy keyhole notch, and broken in impact. The impact value compared with the impact value of the steel in the "as received" condition gives an indication of any deleterious effects from the welding.

A possible use of the tension impact test, namely, to determine the dynamic as distinct from the static properties of materials, has long been recognized, but the difficulties of obtaining values for the instantaneous stresses and strains that occur under impact have largely been impossible to overcome. A pioneer attempt to develop such a test was reported by D. S. Clark and G. Datwyler (California Institute of Technology) in which a dynamometer for measuring the forces and a cathode ray oscillograph for recording and correlating the force and time are used. From the results obtained with this apparatus it has been possible to draw force-elongation diagrams for dynamic loadings corresponding to stress-strain diagrams for static loading. Initial tests with the apparatus lead the authors to conclude that for most materials the yield and maximum forces are higher with dynamic loading than with static loading.

The theory of impact testing as contrasted with the uses of impact tests was the subject of a paper by D. J. McAdam, Jr., (Bureau of Standards) and R. W. Clyne (American Steel Foundries). Two signifi-

cant sentences may be cited: "An impact test should not be limited to metals that are to be subjected to impact in service. The object of an impact test should be to determine whether a structure or machine would be in danger of failure from brittleness under service conditions." As an example, the authors point out that if resistance to plastic deformation in a material becomes greater than its resistance to cohesive failure (from increased velocity of deformation or decrease in temperature) a brittle rather than a fibrous fracture will result. It is this fact that the impact test should bring out. One of the important conclusions of the paper is that if an impact test reveals no evidence of cold brittleness, only minor importance should be assigned to the numerical impact value. Finally, it is concluded that "The quality of the steel, with the exception of its tendency to cold brittleness, is best evaluated in terms of static strength and ductility."

Developments in cement

Compared with recent years, developments in cement specifications were of minor character. The definition of portland cement, which permits additions of non-harmful materials up to amounts of 1 per cent, which was incorporated in the high-early-strength specification last year, was voted into the standard portland cement specification this year. The two standards for portland cement thus are now in agreement on the question of admixtures. Likewise, in the high-early-strength cement specification, the requirement covering fineness was deleted in accordance with similar action taken last year on the standard portland cement specification. This change is in line with the present thinking that fineness of cement is a detail of manufacture that is adequately covered, so far as the user is concerned, by the other physical requirements of the cement.

In the specification for masonry cement, two important revisions were made, namely, increasing the strength requirements (to 350 lb. per sq.in. in 7 days on 2 in. cubes), and second, changing the requirement for water retention to require that a cement mortar after being subjected to a suction for 60 sec. shall have a flow greater than 65 per cent of that immediately after mixing.

Studies continue to be made on the proposed specification for blended cements, the first version of which failed to secure the necessary vote for adoption last year. A new specification, attempting to meet the objections that were raised, has been drafted, but it is still under discussion and was not submitted to a vote.

The only adverse report of the cement committee was to announce the rejection of recommended requirements for the autoclave test developed by the working committee on volume change and soundness of portland cement. The recommendations were based upon conclusions from an elaborate series of tests of 35 cements in which the principal feature was the determination of the expansion of neat bars of the cements when subjected to an autoclaving at a pressure of 295 lb. per sq.in. From the extended discussion it was evident that unanimity of opinion as to the significance or utility of the autoclave test is still lacking.

An investigation to determine the effect of replacing a portion of the portland cement with a natural cement in mortars and concrete was reported by W. F. Kellermann and D. G. Runner (Bureau of Public Roads). In addition to tests on laboratory specimens, a series of tests was made on cores taken from four concrete pavements in New York State in which two different natural cements were used as admixtures to reduce surface scaling. The core specimens were subjected to alternate freezing and thawing tests while for the laboratory specimens a wide range of physical properties of both mortars and concrete was also determined. The general conclusion from the tests was that although the strength was reduced by replacement of the portland cement with natural cement, resistance to alternate freezing and thawing was for certain combinations of materials substantially increased. The core tests indicated that one of the natural cements did not improve the resistance of the concrete to the same extent as did the other. In discussion, Ira Paul of the New York state department of public works stated that any differences that existed between the two natural cements were not evident from laboratory studies. F. H. Jackson, (Bureau of Public Roads) remarked that pavement scaling probably is the result of water gain, and the effect of the natural cement is to reduce such bleeding. He suggested that other admixtures might produce the same beneficial results as natural cements.

Increased knowledge of concrete

Reports of concrete research, as usual, produced significant information. In a progress report of a long range program of research, aimed toward a better understanding of concrete shrinkage, Roy W. Carlson (Massachusetts Institute of Technology) gave an enlightening analysis of the subject, with the tentative conclusion that the rigidity, or modulus of elasticity, of the aggregate largely determines whether or not the concrete will have a high or low shrinkage. If the cement paste in ordinary concrete were not restrained by the aggregate, he pointed out, it would shrink 5 to 15 times as much as does the concrete. It was further concluded that, for a concrete of gravel and a standard cement, neither the cement content, the gradation of the aggregate nor the duration of preliminary moist curing has much effect on shrinkage. An appreciable reduction in shrinkage can however be obtained by adding ½ per cent of ground mica to the mix, thus reducing the tensile strength of the mortar. The type of aggregate used has the greatest effect on concrete shrinkage. Among the pure mineral aggregates, dense grades of quartz, feldspar, dolomite and limestone were outstanding in producing low shrinkage, while hornblende and pyroxene, and aggregates of mixed composition, such as slate and sandstone, produced concrete of very high shrinkage. Granite was intermediate between aggregates producing high and low shrinkage in accordance with its varying constituents. In the final analysis it is the cement paste that produces the shrinkage, and it is the purpose of the aggregate to reinforce the concrete against this contraction.

The subject of bond strength in reinforced concrete, which has been given little consideration in the laboratory for a number of years, was revived in a paper reporting tests at the University of California. The authors, Raymond E. Davis, Elwood H. Brown, and J. W. Kelly, reported a series of tests based upon the concept that the character and quality of a cement paste, particularly the volumetric behavior of the paste as it

sets and hardens, exerts an important influence on the bond between concrete and reinforcing steel. It was concluded that the tightness with which the steel is gripped by the surrounding concrete, while dependent upon paste strength and rigidity, may often be more dependent upon the tendency of the paste to expand or contract with moisture and thermal changes.

To circumvent the laborious operation of determining the modulus of elasticity of concrete by stress-strain measurements, T. C. Powers (Portland Cement Association) described a method of using sonic vibrations which, by contrast is simple, speedy, and, in in his opinion, more accurate. It makes use of a mathematical relationship existing between the frequency of vibration of a bar or rod of elastic material and Young's modulus E. Using mortar bars, 2x2x9½ in. in size, Mr. Powers determined their frequency by comparison with a set of orchestra bells, calculated the modulus of elasticity and found excellent agreement with results from stress-strain measurements.

Results of tests on short time creep of concrete in compression were reported by Russell S. Jensen and Frank E. Richart of the University of Illinois. The creep involved was that which occurs in concrete in relatively short periods of time, varying from 1 to 30 min., under various intensities of stress, and carbon pile telemeter gages were used for measuring loads and strains in combination with an oscillograph recorder. The tests, which were sponsored by the society group concerned with the effect of speed of testing, were made on 6x12-in. cylinders, with four grades of concrete strengths. The results indicate that long and short time creeps are fundamentally the same in nature though the long-time rate may be modified by moisture changes and similar conditions which do not exist in the short time observations.

Specification changes in the field of concrete and concrete aggregates were characterized by changes in the status of a number of specifications from tentative standards to standards and the adoption of three new tentative methods of test for (1) determination of yield of concrete; (2) soundness of aggregate by freezing and thawing; and (3) sieve analysis of fine and coarse aggregates. The latter new tentative specification replaces four standard methods of test concerned with the mechanical analysis of various types of aggregates.

The torsion test

Dr. Albert Sauveur, professor-emeritus of metallurgy at Harvard University, delivered the annual Edgar Marburg Lecture, taking as his theme "The Torsion Test", of which subject he has made a special study at Harvard for some years past. At the outset he emphasized that it is a custom of long standing to test and rate metals by their tensile resistance, although tension failures are not the most common, most failures occurring under a combination of tension and compression, which means shear or torsion.

The average torsional strength of metals, as shown by many tests made at Harvard on a specially designed torsion machine during the past few years, is 0.68 per cent of the "true" tensile strength, that is, the tensile stress at failure on the reduced section. Most metals break on reaching a limiting twist, but highly ductile metals, as copper, twist almost indefinitely; for these latter Dr. Sauveur recommended taking as ultimate strength the torque at 360 deg. twist. Time-strain diagrams are either smooth or stepped. Single crystals tested in torsion gave stepped diagrams, while polycrystalline aggregates of the same metals gave smooth curves. One marked feature of the torsion test is that hysteresis loops can be run, throwing light on certain characteristics of a metal not revealed by the simple tension test.

Steel studies and specifications

Steel research and studies of the past year were not reflected in the usual number of specification changes so far as construction industry materials are concerned. The structural nickel steel specification was changed from tentative standard to standard rating, and the structural steel subcommittee reported that its present studies cover consideration of the status of steel sheet piling specifications; requirements for structural bolts; requirements for manganese-vanadium structural shapes and rivet stock; and consideration of high-strength rivet specifications.

The behavior of the so-called stainless steels under conditions of actual service is being studied by a special subcommittee which has inspected the architectural installations on the Chrysler and Empire State buildings in New York City, on the Philadelphia Savings Fund Society building in Philadelphia, and on store fronts in various cities. It is expected that a final report will be available in about six months.

In the field of corrosion the subcommittee on field tests of metallic coatings of steel sheets, shapes and hardware reported results of a further inspection without altering the previous conclusion that the weight of coating is the principal characteristic that determines long life, and that the quality of the zinc or the type of the base metal is relatively unimportant. R. F. Passano (American Rolling Mill Co.) in reporting on the field tests on galvanized sheets, described the nature of the corrosion breakdown at the various test locations. At the four northern test sites, disappearance of the zinc coating from the exposed surface precedes failure or perforation of the base sheet by an appreciable length of time. At the fifth test location in Key West, Fla., on the other hand, perforation of the sheet from the under surface precedes any apparent breakdown of the coating on the exposed surface; the latter surface at Key West is becoming covered with an adherent, white paint-like layer that retards deterioration of the zinc.

Cast iron developments

Specification changes in the field of cast iron involve gray iron castings for valves and pipe fittings and cast iron culvert pipe. In the pipe fitting specification, a new Class C iron with higher strength requirements (41,000 lb. per sq. in. in tension) than the existing two classes has been added. The culvert specification was adopted as standard after revisions were made eliminating test specimens of full-length pipe (unless specifically ordered by the purchaser) and substituting ring specimens, 1 to 4 ft. long, cut from the spigot ends of the pipe.

Research on cast iron at the University of Illinois, begun several years ago to find a possible correlation among the strengths of the same iron in tension, compression, bending and torsion, is making progress. Last year J. O. Draffin and W. L. Collins

reported the tension test results and at the recent meeting the same authors presented a paper on their torsion tests. Solid and hollow machined specimens were used. For the solid specimens in torsion the modulus of rupture, modulus of elasticity and maximum tensile unit strain were practically the same for specimen diameters of 1 in. and ¾ in. For hollow specimens, with walls ⅛ in. thick, or at t r ratio (wall thickness divided by outside radius) of 0.243, the modulus of rupture decreased from about 39,000 lb. per sq. in. for the solid specimen (t/r = 1) to about 27,000 lb. per sq. in., the latter being the strength of cast iron in direct tension. For the hollow specimens in torsion, the maximum tensile unit strain decreased from about 0.02 in. per in. in the solid ones to 0.0076 in. per in. for a t/r of 0.243, the maximum tensile unit strain in direct tension being about 0.006 in. per in.

Fatigue of metals

Reporting for the research committee on fatigue of metals, H. F. Moore (University of Illinois), said that an extensive test series on two steels on three or four different types of machine is projected, to explore the machine influence on the results.

J. B. Kommers (University of Wisconsin, Madison) in an extended report on "The Effect of Overstressing and Understressing in Fatigue", showed that repetitive stressing may damage or may strengthen the material, that is, it may reduce the endurance limit or may increase it. Both steel and cast iron were tested, and both materials generally were damaged by overstress preceding the final endurance tests; the amount of damage (expressed by the per cent of lowering of endurance limit) was roughly proportional to the amount of overstressing and to the "cycle ratio" of the overstress—that is, the ratio of actual overstress cycles to the number of cycles that would have produced rupture. Further tests, in which repetitive understressing was applied after the period of overstressing, "showed that the damage that had been done by overstress could be repaired by progressively increasing understress", sometimes increasing the endurance limit above the original overstress. It was concluded that "the damage done by overstress is not always permanent", and that the endurance limit of a material is not a fixed quantity but can be changed by various stressing operations.

Non-ferrous metals

New data on non-ferrous metals of significance to the civil engineer were presented in a paper on the properties of the various types of monel metal by Charles F. Catlin and W. A. Mudge (International Nickel Co.) which included data on the new "K" monel, an alloy of aluminum, copper and nickel that has recently found application in large valve rods, 7 to 8½ in. in diameter and up to 22 ft. long, at Tygart and Grand Coulee dams. The metal offers an unusual combination of strength, hardness and ductility when age-hardened, and in addition has high resistance to torsion impact, according to the authors. Typical physical values for cold-drawn age-hardened *K* monel from tests reported in the paper are: tension yield strength (at 0.1 per cent offset) 115,650 lb. per sq.in.; compression yield strength, 119,000; ultimate tensile strength, 157,650; reduction in area, 37.5 per cent; elongation in 2 in., 22 per cent. When hot-rolled and age-hardened, the material is more ductile but has slightly lower tensile values. An important characteristic of this material is that it fails without fracture.

A report of the results of the third series of atmospheric corrosion tests on 9x12-in. plate specimens of 24 non-ferrous metals and alloys exposed in 1931 in nine test locations was presented by the committee which has the work in charge. The extent of corrosion is determined by various procedures but at present only the losses in tensile properties are significant. According to the recent 6-yr. tests, substantial losses in tensile strength or percentage elongation or both have occurred at most of the industrial and seacoast locations for three samples of zinc, for commercial aluminum, aluminum alloys, manganese bronze, 70-30 brass, and tin. With the exception of the 70-30 brass and manganese bronze, the losses in tensile properties of the coppers and other copper alloys are so small as to be of little significance. The same is true for nickel and the high nickel-copper alloys as well as for lead and the lead-antimony alloys. In the rural locations the losses of tensile properties are negligible for all materials except tin. It was announced that the next series test will be made in about 10 or 12 years, at which time one set of plates which has never been removed from the test racks will be tested along with the others which have been removed at 1, 3, and 6-yr. intervals.

Unit masonry research

Research in brick and tile was presented in three papers, and the results of other research was reflected in several specification changes in the field of so-called manufactured masonry units. Outstanding among the papers was a report of an investigation by J. W. McBurney and A. R. Eberle (Bureau of Standards) to determine the effect on brick disintegration of various freezing and thawing tests. At the present time there is a total lack of standards for making such tests on structural clay products.

The general conclusion of the authors is that for both laboratory freezing methods and natural exposures the greater the degree of saturation at the time of freezing, the more effective is the method in producing disintegration. In so far as detailed results were concerned, the following may be cited: (1) the nature of the brick influences the relative effect of differences in the methods of test; (2) the use of whole or half bricks as test specimens does not significantly affect the results; (3) with the exception of one type of brick, methods which allowed the saturation of the sample to increase were more severe than methods which reduced saturation by drying after every three cycles; (4) if oven drying had any disintegrating effect on the brick samples, it was masked by the effect in lowering saturation; (5) with the exception of the same type of brick mentioned above, freezing in contact with water was more severe than freezing in air. The one type of brick which behaved differently than the others was a "light hard" dry-press clay brick. Considering all the methods of test this brick was the most durable of the five types tested. The authors believe that 50 cycles of an initially severe test are sufficient to test brick durability, but until other tests now under way on panels and walls are completed the question of a standard freezing

and thawing test cannot be approached with much confidence.

An investigation of methods of capping structural clay tile, being carried out at Rensselaer Polytechnic Institute, was described by Prof. T. R. Lawson, in which three types of capping materials—plaster-of-paris, 1:1 mortar using high-early-strength cement, and sulphur mineral compounds — have been studied. Plaster-of-paris is found to be especially affected by moisture, which lowers the strength, and by temperature, which raises the strength. The mortar, which attained a strength of 5,000 lb. per sq.in. in three days on cube specimens, was fairly satisfactory, but a sulphur mineral compound proved to be best, attaining a strength of 7500 lb. per sq. in. in. This latter capping material was most efficient when its strength was about the same as that of the tile. In discussion of the report, D. E. Parsons (Bureau of Standards) pointed out that there is a point of view that holds that the capping material need not be as strong or stronger than the clay tile, but rather that it should simulate the strength of the bedding material that would be used in laying it up.

Another investigation of unit masonry, carried out to determine the effect of shape of pier specimen on compressive strength, was reported by W. J. Krefeld, (Columbia University). A total of 30 masonry piers of two cross-sections (8x16 and 12x16 in.) and of heights ranging from 8.5 to 97 in. (3 to 35 courses) was tested. The same type of brick and a single mortar mix were used in all piers. The tests indicated that the variation of strength of the piers with changing ratio of height to thickness (h/t) follows a common relationship, and that at an h/t ratio of 6 or greater, the strength approaches a constant value; for smaller ratios the apparent strength is increasingly greater, being influenced by a form factor. It is further concluded that suitable correction factors can be determined to permit the use of relatively short piers for test specimens although it is not available to adopt a specimen with an h/t ratio of less than 3 or 4 due to the pronounced influence of shape.

In so far as concrete units are concerned, a new tentative specification for those used in catch basins and manholes was adopted. A new specification for sand-lime building brick was also adopted by the meeting to replace the present standard specification, as a result of tests which showed that resistance to frost action is closely related to strength. In the field of glazed brick and tile, plans are being made to cooperate with Rutgers University in carrying out a survey of the properties of these building units.

A special committee is undertaking the preparation of a list of sizes of building units which conform to a single module. At the meeting, a 4-in. module was adopted, and a list of sizes will soon be issued. The purpose of the module will be to make possible the assembly of various structural members of a building without extensive cutting and waste.

After extended discussion and argument the committee on lime recommended the abandonment of the soundness test in Specification C110-34T, since it is held to produce laboratory results at variance with field experience. Also, it is maintained that the standard constancy of volume test in Specification C6-31 adequately protects the consumer. In withdrawing the soundness test, the committee voted, however, to continue its investigation of methods for determining the soundness of lime and to present a progress on the work at the next annual meeting.

Studies of road materials

Asphalts treated with sulphur showed marked improvement in brittleness, stability, density and water absorption, according to tests reported by I. Bencowitz and E. S. Boe (Texas Gulf Sulphur Co.). The sulphur-treated asphalt flows more easily when hot but has a higher yield point at normal temperatures and therefore may prove useful to the roofing engineer. While there is no convincing evidence as to whether the effect is chemical or results from the mineral filler, penetration tests indicate a marked difference between the action of sulphur and such fillers as silica dust or carbon black. T. G. Delbridge (Atlantic Refining Co.), however, held that the main effect is probably mechanical, as the fact that solvents crystallize the sulphur out suggests that only a small part of the sulphur combines with the asphalt.

Granular materials were investigated extensively for the relation between grading and density by Prof. D. M. Burmister (Columbia University). Prof. Burmister classified usual logarithmic grading curves into five different types, each of which has an individual density relation. He also expressed fineness or grain size in terms of a size factor, which is 1/100 of the net area under the grading curve between the ¾-in. and the 0.001 millimeter size, or in other words a weighted geometric mean grain size over this range. By use of size factor and grading curve type, the author believes that the properties of granular materials in either original condition or mixture may be defined more clearly than heretofore.

A new test method applicable to soils was described and demonstrated by E. O. Rhodes (Koppers Co.). It was developed because analyses and tests of various soils for determining best stabilization procedure showed existing test methods to be inadequate and indicated the need for better instruments and better test methods in both field and laboratory. The energy absorbed in kneading the soil was therefore adopted as a measure of consistency, and to use this measure a machine called the "plastograph" was built. It consists of a small pugmill in which a sample of the soil is mixed or kneaded at constant speed of drive while water is dropped into the mass at a fixed rate. An autographic device plots a curve of mixture torque against time, or in other words a curve of stiffness (energy absorption) against moisture.

Tests with this machine on soils known to be satisfactory and stable road soils on one hand, and bad or treacherous soils on the other hand, showed that the former produce flat curves while the latter develop a sharp rise to a high maximum energy absorption followed by a drop to low values, the latter decreasing further to virtually zero. Preliminary check of a number of such curves against values obtained by conventional soil tests—for shrinking limit, plastic limit and liquid limit—indicated that there is a rough correspondence between shrinkage limit and initial point of rise of the curve, between plastic limit and apex of the curve, and between liquid limit and lower point of drop of the curve. It was found that the plastograph curves reproduce with great accuracy in repeat tests on the same road material.